

AUTOFOCUS APPARATUS

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The entire disclosure of Japanese Patent Application Nos. 8-85192, 8-85193, 8-116742, 8-116743, 5 8-154086 and 8-154087 including specifications, claims, drawings and summaries is incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

10 Field of the Invention

The present invention relates to an autofocus apparatus and a camera that are used for a camera, mainly for a video camera and particularly for a TV camera. The present invention also relates to a lens 15 barrel and a camera that are used chiefly for a lens interchangeable type video camera and particularly for a lens interchangeable type TV camera.

Related Background Art

There have hitherto been two kinds of autofocus 20 apparatuses as an autofocus apparatus for a camera. One type is generally called a crest climbing type autofocus apparatus used for mainly a video camera. The other type is called an image deviation type autofocus apparatus employed for chiefly a still 25 camera. The two types of autofocus apparatuses will hereinafter be described with reference to the drawings.

First of all, the crest climbing type autofocus

apparatus will be explained with reference to Figs. 1 and 2. Fig. 1 is a schematic block diagram illustrating the crest climbing type autofocus apparatus. Fig. 2 is an explanatory graph showing a relationship between a level of a high frequency component of a picture signal.

The crest climbing type autofocus apparatus includes, as illustrated in Fig. 1, a photographing optical system 90 constructed of a focus adjusting lens 901, a variable magnification lens 902, a correcting lens 903, a stop 904 and an image forming lens 905. This autofocus apparatus also includes an imaging element 91 for picking up an image formed by the photographing optical system 90 and converting it into an electric signal, a picture signal making device 92 for generating a picture signal corresponding to the electric signal transmitted from the imaging element 91, and a focusing estimated value creating device 93 for creating an item of data (a focusing estimated value) for focusing the image formed on the imaging element 91 on the basis of the picture signal transmitted from the picture signal making device 92. The crest climbing type autofocus apparatus further includes a motor 94 for moving the focus adjusting lens 901 in an optical-axis direction of the photographing optical system 90, and a motor driving device 95 for driving the motor 94 referring to the focusing estimated value obtained by the focusing estimated

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value creating device 93.

Next, an operation of the crest climbing type autofocus apparatus will be explained. To begin with, the photographing optical system 90 forms an image on the imaging element 91. This image is, after being converted into the electric signal by the imaging element 91, further converted into the picture signal by the picture signal making device 92. This picture signal can be regarded as being formed by synthesizing sine waves of a plurality of frequencies.

By the way, it is well known that the level of the high frequency component of the picture signal, as shown in Fig. 2, rises more steeply as a degree of sharpness of the image formed on the imaging element 91 increases, viz., as the focus adjusting lens move closer to a focusing point A. Then, it is also a generally known fact that when the image on the imaging element 91 is focused on, the high frequency component level of the picture signal reaches its peak. Further, a crest of this level has a tendency of becoming steeper with a higher frequency. While on the other hand, an image forming performance of the lens and an S/N ratio of the picture signal worsen as the frequency gets higher.

Such being the case, the focusing estimated value creating device 93 selects a proper high frequency component from the picture signal obtained by the picture signal making device 92 in consideration of the

S/N ratio of the picture signal as well as of the image forming performance of the photographing optical system 90, and creates a focusing estimated value by monitoring the level of this frequency component at an adequate sampling interval. For example, when the level of the selected frequency component is rising, it is estimated that the focus adjusting lens 901 is moving in such a direction as to approach a focusing point. Contrastingly, when the level of the selected frequency component is lowering, it is estimated that the focus adjusting lens 901 is moving in such a direction as to get away from the focusing point. Then, when the level of the selected frequency component exists within a predetermined range (shown by e.g., ΔV in Fig. 2), it is estimated that the image on the imaging element 91 is focused on.

Next, the motor driving device 95 refers to the focusing estimated values sequentially sent from the focusing estimated value creating device 93, and drives the motor 94 to move the focus adjusting lens 901 to such a position as to make a judgement of being focused on. Thus, in the crest climbing type autofocus apparatus, the focus adjusting lens 901 moves as if climbing the crest of the high frequency. This is the reason why the above autofocus apparatus is called the crest climbing type.

The above crest climbing type autofocus apparatus estimates the focusing by use of the picture signal and

is therefore capable of highly accurately focusing the image on the imaging element 91 upon the corresponding object. Further, the image on the imaging element 91 is focused on without providing an element for an
5 exclusive use of measuring a distance, and hence there must be an advantage costwise. Therefore, the apparatus is used as the autofocus apparatus mainly for the video camera.

Next, the image deviation type autofocus apparatus
10 will be explained with reference to the drawings. Figs. 3, 5 and 7 are explanatory diagrams each showing what the principle of the image deviation type autofocus apparatus is. Herein, Fig. 3 illustrates a light path when in a focused state. Figs. 5 and 7 show
15 the light paths when in a defocused state. Further, throughout the drawings, the numeral 96 designates an image forming optical system for forming the light beams into a conjugate image. The numeral 97 represents a predetermined focal surface of the image
20 forming optical system 96, and 98a, 98b denote image re-forming lenses, disposed in positions substantially symmetric with respect to the optical axis of the image forming optical system 96, for re-forming some of the light beams (image) into images, which beams have been
25 image-formed by the image forming optical system 96. Designated further by 99a, 99b are line sensors disposed in positions substantially symmetric with respect to the optical axis of the image forming

optical system 96 and on predetermined focal surfaces of the image re-forming lenses 98a, 98b.

As illustrated in Fig. 3, when the light beams passing through the image forming optical system are focused on the predetermined focal surface 97, some of the light beams are again image-formed on the line sensors 99a, 99b through the image re-forming lenses 98a, 98b. Accordingly, when focused on the predetermined focal surface 97, images E_1 , E_2 picked up by the two line sensors 99a, 99b are, as illustrated in Fig. 4, formed in substantially coincident positions of the line sensors. On the other hand, as shown in Fig. 5, when the light beams passing through the image forming optical system are focused on anterior to the predetermined focal surface 97 (which is a so-called rear focus state), there must be a deviation between the images E_1 , E_2 picked up by the two line sensors 99a, 99b as shown in Fig. 6. Further, as illustrated in Fig. 7, when the light beams passing through the image forming optical system are focused on posterior to the predetermined focal surface 97 (which is a so-called front focus state), there must be, as illustrated in Fig. 8, a deviation between the images picked up by the two line sensors 99a, 99b in a direction opposite to that in the rear focus state.

Hence, it is feasible to calculate a moving direction and a moving quantity of the focus adjusting lens, which are needed for focusing on the

predetermined focal surface 97, by detecting a deviating direction and a deviation quantity between the images picked up by the line sensors 99a, 99b. As discussed above, in the image deviation type autofocus apparatus, the focusing is performed based on the deviating direction and the deviation quantity between the images picked up by the two line sensors 99a, 99b. This is the reason why the above autofocus apparatus is called the image deviation type.

10 The above-described image deviation type autofocus apparatus directly calculates the required-for-focusing moving direction and moving quantity of the focus adjusting lens on the basis of the deviating direction and the deviation quantity between the images picked up
15 by the two line sensors 99a, 99b, and is therefore capable of focusing quickly. The image deviation type autofocus apparatus is therefore used mainly for the still camera.

20 Principally, the crest climbing type autofocus apparatus has hitherto been used for the video camera. The video camera to which the conventional crest climbing type autofocus apparatus is applied, will hereinafter be explained with reference to the drawings. Fig. 9 is a schematic block diagram showing
25 the video camera to which the prior art crest climbing type autofocus apparatus is applied. Fig. 2 is an explanatory graph showing how a level of a high

frequency of the picture signal relates to a position of the focus adjusting lens.

The video camera to which the conventional crest climbing type autofocus apparatus is applied includes, as illustrated in Fig. 9, a lens barrel 8 and a camera body 9 to which the lens barrel 8 is attached.

The lens barrel 8 is so constructed as to be attachable to the camera body 9, and a user is able to interchange the lens barrel 8 attached to the camera body 9 according to applications thereof. Further, the lens barrel 8 has a photographing optical system constructed of a focus adjusting lens 801, a variable magnification lens 802, a correcting lens 803, a stop 804 and an image forming lens 805. The lens barrel 8 also has a motor 122 for moving the focus adjusting lens 801 in the optical-axis direction of the photographing optical system 120, and a motor driving circuit 123 for driving the motor 122 based on a motor driving signal transmitted via a connector 125.

The camera body 9 includes an imaging element 91 for picking up the image obtained by the photographing optical system 120 and converting it into an electric signal, a picture signal making device 92 for generating a picture signal corresponding to the electric signal transmitted from the imaging element 91, and a focusing estimated value creating device 93 for creating the data (a focusing estimated value) for

focusing the image on the imaging element 91 on the basis of the picture signal from the picture signal making device 92. The camera body 9 also includes an AF processing circuit 104 for generating a motor
5 driving signal with reference to the focusing estimated value obtained by the focusing estimated value creating device 93, and a connector 105 through which the motor driving signal generated by the AF processing circuit 104 is transmitted to the motor driving circuit 123 of
10 the lens barrel 8. Note that the connector 105 is so constructed as to be electrically connected to a connector 125 of the lens barrel when the lens barrel 8 is attached to the camera body 9.

Next, an autofocus operation of the video
15 camera shown in Fig. 9 will be explained. At the first onset, the photographing optical system 120 forms the image on the imaging element 91. This image is converted into the electric signal by the imaging element 91 and thereafter converted further into the
20 picture signal by the picture signal making device 92. This picture signal can be regarded as being formed by synthesizing sine waves of a plurality of frequencies.

By the way, it is well known that the level of the high frequency component of the picture signal, as
25 shown in Fig. 2, rises more steeply as a degree of sharpness of the image formed on the imaging element 91 increases, viz., as the focus adjusting lens move

closer to a focusing point A. Then, it is also a generally known fact that when the image on the imaging element 91 is focused on, the high frequency component level of the picture signal reaches its peak. Further, a crest of this level has a tendency of becoming steeper with a higher frequency. While on the other hand, an image forming performance of the lens and an S/N ratio of the picture signal worsen as the frequency gets higher.

Such being the case, the focusing estimated value creating device 93 selects a proper high frequency component from the picture signal obtained by the picture signal making device 92 in consideration of the S/N ratio of the picture signal as well as of the image forming performance of the photographing optical system 120, and creates a focusing estimated value by monitoring the level of this frequency component at an adequate sampling interval. For example, when the level of the selected frequency component is rising, it is estimated that the focus adjusting lens 801 is moving in such a direction as to approach a focusing point. Contrastingly, when the level of the selected frequency component is lowering, it is estimated that the focus adjusting lens 801 is moving in such a direction as to get away from the focusing point. Then, when the level of the selected frequency component exists within a predetermined range (shown by

e.g., ΔV in Fig. 2), it is estimated that the image on the imaging element 91 is focused on.

Next, the AF processing circuit 104 refers to the focusing estimated values sequentially sent from the focusing estimated value creating device 93, and
5 generates a motor driving signal to move the focus adjusting lens 801 to such a position as to make a judgement of being focused on. The motor driving circuit 123 drives the motor 122 based on the motor
10 driving signal generated by the AF processing circuit 104.

Thus, in the crest climbing type autofocus apparatus, the focus adjusting lens 801 moves as if climbing the crest of the high frequency. This is the
15 reason why the above autofocus apparatus is called the crest climbing type.

The video camera to which the above crest climbing type autofocus apparatus is applied, estimates the focusing by use of the picture signal and is therefore
20 capable of well accurately focusing on the object corresponding to the image on the imaging element 91. Further, this video camera is advantageous costwise because of focusing the image on the imaging element 91 without providing an element for an exclusive use of
25 measuring a distance.

In the above-described crest climbing type autofocus apparatus, the focus adjusting lens 901 is

moved to such a position as to make the judgement of being focused while referring to the focusing estimated values sequentially transmitted from the focusing estimated value creating device 93 at a predetermined sampling interval. This might lead to a problem, in which it takes much time to attain the focusing. Especially when the focus adjusting lens 901 is positioned far from the focusing point (which is a so-called largely defocused state), as illustrated in Fig. 2, a variation in the high frequency component level of the picture signal might be small enough to be hidden by noises, etc., or there must be a high possibility of not indicating a peak of the level thereof. Consequently, the focusing estimated value creating device 93 becomes harder to make the estimation. Therefore, the time till the focusing is attained might extremely elongate in some cases.

The problem of requiring a good deal of time for focusing might bring about a possibility in which the photographer would miss an instantaneous photographing chance on the occasion of reporting news and so forth when, e.g., the above crest climbing type autofocus apparatus is used for the TV camera.

In this respect, the above image deviation type autofocus apparatus is, as stated earlier, capable of focusing quickly. When the image deviation type autofocus apparatus is employed for the video camera,

however, it is required that the light beams be
diverged from the photographing optical system for
forming the image on the imaging element, and the image
be formed in a position different from the imaging
5 element surface. Therefore, whether or not the image
on the imaging element be focused on is estimated by
making use of the image formed in the position
different from the imaging element surface. Hence,
this leads to a problem of being incapable of focusing
10 with a high accuracy. The high accuracy (a deviation
on the image surface in the optical-axis direction of
the photographing optical system is within
approximately several μm), is required of particularly
the autofocus apparatus for the TV camera. Meeting
15 this accuracy in the above image deviation type
autofocus apparatus must involve a remarkable increase
in costs.

Further, in the video camera to which the above
prior art crest climbing type autofocus apparatus is
20 applied, the focus adjusting lens 801 is moved to such
a position as to make the judgement of being focused
while referring to the focusing estimated values
sequentially transmitted from the focusing estimated
value creating device 93 at the predetermined sampling
25 interval. Therefore, the problem is that the focusing
might need much time. In particular, when the focus
adjusting lens 801 is positioned far from the focusing

point (which is the so-called largely defocused state), as shown in Fig. 2, the level of the high frequency component of the picture signal remains almost unchanged even by moving the focus adjusting lens 801.

5 Hence, the focusing estimated value creating device 93 is hard to make the estimation in terms of considering the noises, etc. contained in the high frequency components. Consequently, the time needed till the focusing is attained might extremely elongate in some
10 cases. The problem of requiring a good deal of time till the focusing is done might further conduce to the possibility, wherein the photographer would miss the instantaneous photographing chance on the occasion of reporting news when, e.g., the above-described crest
15 climbing type autofocus apparatus is used for the TV camera.

Moreover, in the video camera to which the above prior art crest climbing type autofocus apparatus is applied, as illustrated in Fig. 9, the camera body
20 incorporates the focusing estimated value creating device and the AF processing device. Therefore, in the video camera, both of the camera body corresponding the autofocusing and the lens barrel corresponding to the relevant camera body, are needed for actualizing the
25 autofocus function. Particularly the camera body of the TV camera employed by a professional cameraman is, however, very expensive and therefore causes such a

problem that the user is forced to expend much in order to actualize the autofocus function in that TV camera.

Furthermore, when replacing the lens barrel attached to the video camera body, a so-called tracking
5 adjustment is required to be performed, wherein a predetermined focal surface of the lens barrel is adjusted to the imaging element surface of the video camera body by moving the image forming lens of the lens barrel in the optical-axis direction of the lens
10 barrel. Upon carrying out the tracking adjustment, there must be produced a deviation in an optical positional relationship between the imaging element surface of the video camera body and the predetermined focal surface 97 for estimating the focusing, resulting
15 in a decline in terms of the focusing accuracy.

SUMMARY OF THE INVENTION

It is a primary object of the present invention, which was contrived under such circumstances, to
20 provide an autofocus apparatus, a camera and a lens barrel that are inexpensive and capable of focusing quickly with a high accuracy.

It is another object of the present invention to provide a lens barrel capable of actualizing an
25 autofocus function even when attached to a camera body incorporating no autofocus function.

It is a further object of the present invention to

provide an autofocus apparatus capable of focusing on a photographing target at a high efficiency.

To accomplish the above objects, an autofocus apparatus according to the present invention comprises

5 a photographing optical system having at least a focus adjusting lens disposed movably and an optical element for splitting light beams inputted and emerging from an object. The autofocus apparatus also comprises a first focusing estimating device having a first optical

10 system for forming an image corresponding to the object by inputting one light beam of the light beams split by the optical element, a first imaging element for picking up the image obtained by the first optical system and converting it into an electric signal, and a

15 first data creating device for selecting a proper frequency component from the electric signal obtained by the first imaging element and, on the basis of a level of this frequency component, creating an item of data for focusing the image on the first imaging

20 element upon the object. The autofocus apparatus further comprises a second focusing estimating device having a second optical system for forming an image corresponding to the object by inputting the other light beam of the light beams split by the optical

25 system, an image re-forming optical system for respectively re-forming, into images, the light beams passing through portions with different pupils among

the light beams for forming the image formed by the second optical system, a second imaging element for picking up the images obtained by the image re-forming optical system, and a second data creating device for
5 creating an item of data for focusing the image on the first imaging element upon the object on the basis of a positional deviation between the images on the second imaging element. The autofocus apparatus still further comprises a focusing estimation selecting device for
10 selecting at least one item of data out of the data given from the first focusing estimating device and the data from the second focusing estimating device, and a moving device for moving the focus adjusting lens on the basis of the data selected by the focusing
15 estimation selecting device.

Herein, it is preferable that the focusing estimation selecting device selects the data from the second focusing estimating device when the image picked up by the first imaging element is roughly focused on,
20 and selects the data from the first focusing estimating device when the image picked up by the first imaging element is finely focused on.

Further, the focusing estimation selecting device, if any one item of the data of two items of data from
25 the first focusing estimating device and from the second focusing estimating device is useless, may select the other item of data. Herein, "being useless"

implies a case in which the image on the first imaging element can not be focused with that estimated value.

It is because, as described in the prior art, the principle of the crest climbing method is absolutely
5 different from that of the image deviation method, and the focusing point is undetectable depending on the objects as the case may be.

Furthermore, the focusing estimation selecting device may select any one item of data of two items of
10 data from the first focusing estimating device and from the second focusing estimating device with reference to data for specifying a depth of field. Herein, the "data for specifying the depth of field" correspond to, e.g., an aperture value of the photographing optical
15 system, positions of the focus adjusting lens and of the variable magnification lens in the photographing optical system, and an existence or non-existence and a kind of an optical accessory.

The autofocus apparatus according to the present
20 invention may further comprise an object dimension calculating device for calculating a real dimension of the object on the basis of a distance from an image side principal point of the photographing optical system to an image surface, a distance from an object-
25 side principal point of the photographing optical system to the object, and a dimension of the object on the first imaging element. The autofocus apparatus may

still further comprise an object dimension setting device for setting a dimension of the object, and a focusing object controlling device for comparing the object real dimension calculated by the object dimension calculating device with the object dimension set by the object dimension setting device, and controlling the first focusing estimating device and the second focusing estimating device on the basis of a result of this comparison.

10 The real dimension Y of the object is expressed by the following formula:

$$Y = ay / b$$

where b is the distance from the image side principal point of the photographing optical system to the image surface, a is the distance from the object-side principal point of the photographing optical system to the object, and y is the dimension of the object on the first imaging element. Herein, the distance a from the object-side principal point of the photographing optical system to the object, can be calculated based on an imaging positional deviation between the images respectively picked up by the plurality of second imaging elements in the second focusing estimating device. Further, the dimension y of the object on the first imaging element can be obtained by executing the image processing on the electric signal transmitted from the first imaging element.

Incidentally, it is preferable that the focusing
object controlling device controls the first focusing
estimating device and the second focusing estimating
device so as to focus on the relevant object when the
5 object real dimension calculated by the object
dimension calculating device is substantially the same
as the object dimension set by the object dimension
setting device, or alternatively the focusing object
controlling device controls the first focusing
10 estimating device and the second focusing estimating
device so as to focus on an object exclusive of the
relevant object.

Moreover, if the second focusing estimating device
is disposed so that the plurality of image re-forming
15 optical systems and the plurality of second imaging
elements are capable of picking up a plurality of
portions of the image formed by the second optical
system, it is preferable that the object dimension
calculating device is capable of calculating the real
20 dimension of respective objects corresponding to the
plurality of portions of the image formed by the second
optical system.

Furthermore, it is preferable that the object real
dimension calculated by the object dimension
25 calculating device is displayed on a display medium
such as a monitor, a finder, etc. or stored on storage
medium such as a video tape or the like together with

the picture signal.

The autofocus apparatus according to the present invention may further comprise a focus area setting device for setting a size of a focus area. The first
5 focusing judging device may create the data for focusing the image on the first imaging element upon the object, with respect to the focus area having the size set by the focus area setting device. Herein, the "focus area" is an area in which to create the data for
10 focusing on the object in an area on the first imaging element.

Note that the focus area setting device preferably sets the size of the focus area of the first focusing estimating device smaller than the focus area of the
15 second focusing estimating device. Further, the focus area setting device may set the size of the focus area of the first focusing estimating device larger than the focus area of the second focusing estimating device.

Moreover, when a plurality of focus areas are
20 previously set in the second focusing estimating device, it is preferable that the focus area setting device detects the focus areas adjacent to each other and having substantially the same distance from the photographing optical system to the object
25 corresponding to the image on the relevant focus area out of the plurality of focus areas on the basis of pieces of data respectively created about the plurality

5 Also, a focus size inputting device for inputting
data about the size of the focus area is provided, and
the focus area setting device may set the size of the
focus of the first focusing estimating device on the
basis of the data about the focus area size inputted by
10 the focus size inputting device.

The autofocus apparatus according to the present invention may be provided with a focus position inputting device for inputting data about a position of the focus area. The first focusing judging device and the second focusing judging device may create the data for focusing the image on the first imaging element upon the object with respect to the focus area existing in the position inputted by the focus position inputting device.

Displayed also on a display medium such as a

monitor, a finder, etc. are the data by which the focus area of the first focusing estimating device can be identified when the focusing estimation selecting device selects the data obtained by the first focusing
5 estimating device, and the data by which the focus area of the second focusing estimating device can be identified when selecting the data obtained by the second focusing estimating device.

Another autofocus apparatus according to the
10 present invention comprises a photographing optical system having at least a focus adjusting lens disposed movably, and an image forming lens for forming an image corresponding to an object by inputting light beams emerging from the object. The autofocus apparatus also
15 comprises an imaging element for picking up an image obtained by the photographing optical system and converting it into an electric signal, and a data creating device for selecting a proper frequency component from the electric signal obtained by the
20 imaging element, and creating an item of data for focusing the image on the imaging element upon the object on the basis of a level of this frequency component. The autofocus apparatus further comprises a
25 moving device for moving the focus adjusting lens on the basis of the data created by the data creating device. The autofocus apparatus may also comprise a distance measuring device for measuring a distance from

an object-side principal point of the photographing optical system to the object. The autofocus apparatus may further comprise an object dimension calculating device for calculating a real dimension of the object on the basis of the distance, measured by the distance measuring device, from an object-side principal point of the photographing optical system to the object, a distance from an image side principal point of the photographing optical system to an image surface, and a dimension of the object on the first imaging element, an object dimension setting device for setting a dimension of the object, and a focusing object controlling device for comparing the object real dimension calculated by the object dimension calculating device with the object dimension set by the object dimension setting device, and controlling an area in which the data creating device creates the data for focusing the image on the first imaging element upon the object on the basis of a result of this comparison.

Still another autofocus apparatus according to the present invention comprises a photographing optical system having at least a focus adjusting lens disposed movably, and an optical element for splitting light beams inputted and emerging from an object, and a first optical system for forming an image corresponding to the object by inputting one light beam of the light

beams split by the optical element. The autofocus apparatus also comprises a first imaging element for picking up the image obtained by the first optical system, a second optical system for forming the image
5 corresponding to the object by inputting the other light beam of the light beams split by the optical element, and an image re-forming optical system for respectively re-forming, into images, the light beams passing through portions with different pupils among
10 the light beams for forming the image formed by the second optical system. The autofocus apparatus further comprises a second imaging element for picking up the images obtained by the image re-forming optical system, a data creating device for creating an item of data for
15 focusing the image on the first imaging element upon the object on the basis of a positional deviation between the images on the second imaging element, a moving device for moving the focus adjusting lens on the basis of the data created by the data creating
20 device, and an object dimension calculating device for calculating a real dimension of the object on the basis of a distance from an image side principal point of the photographing optical system to an image surface, a distance from an object-side principal point of the
25 photographing optical system to the object, and a dimension of the object on the first imaging element. The autofocus apparatus still further comprises an

object dimension setting device for setting a dimension of the object, and a focusing object controlling device for comparing the object real dimension calculated by the object dimension calculating device with the object dimension set by the object dimension setting device, and controlling an area in which the data creating device creates the data for focusing the image on the first imaging element upon the object on the basis of a result of this comparison.

10 A camera according to the present invention is attachable with a lens barrel comprising a photographing optical system having at least a focus adjusting lens disposed movably, and an optical element for splitting light beams inputted and emerging from an object, a first optical system for forming an image
15 corresponding to the object by inputting one light beam of the light beams split by the optical element, and a moving device for moving the focus adjusting lens. Preferably, the camera comprises a first focusing
20 estimating device having a first imaging element for picking up the image obtained by the first optical system and converting it into an electric signal, and a first data creating device for selecting a proper
25 frequency component from the electric signal obtained by the first imaging element and, on the basis of a level of this frequency component, creating an item of data for focusing the image on the first imaging

Herein, the first focusing estimating device estimates the image on the first imaging element by use of a so-called crest climbing method. As stated in the prior art, it is well known that the level of the high frequency component of the electric signal obtained by

Herein, the first focusing estimating device estimates the image on the first imaging element by use of a so-called crest climbing method. As stated in the prior art, it is well known that the level of the high frequency component of the electric signal obtained by

Moreover, the second focusing estimating device

estimates the image on the first imaging element by use of a so-called image deviation method. The light beams diverged by the photographing optical system, after being image formed by the second optical system, pass
5 through the plurality of image re-forming optical systems and respectively form images on the corresponding second imaging elements. Herein, it is preferable that each of the second imaging elements is disposed to make output signals of the picked-up images
10 coincident with each other when the image on the first imaging element is focused on. The second data creating device detects a deviating direction and a deviation quantity between the images picked up by the respective imaging elements, thereby creating the data
15 (the focusing estimated value) for focusing the image on the first imaging element.

In the autofocus apparatus of the present invention, the first focusing estimating device creates the focusing estimated value by use of the so-called
20 crest climbing method, and the second focusing estimating device creates the focusing estimated value by use of the so-called image deviation method. Then, the focusing estimation selecting device selects at least one of the focusing estimated value created by
25 the first focusing estimating device and the focusing estimated value created by the second focusing estimating device, and the focus adjusting lens is

moved based on the selected focusing estimated value.

Accordingly, the focusing estimation selecting device is set so that at first the image on the first imaging element is roughly focused on by use of the focusing estimated value of the second focusing estimating device, and thereafter the image on the first imaging element is finely focused on by employing the focusing estimated value of the first focusing estimating device. It is therefore feasible to execute focusing quickly with a high accuracy. Further, the high accuracy is not required of the second focusing estimating device using the image deviation method, and hence the costs can be restrained.

Further, if any one of the first focusing estimated value and the second focusing estimated value is useless, the focusing estimation selecting device is set to select the other estimated value, whereby the focusing on the object can be done more surely.

Furthermore, the focusing estimation selecting device is set to select at least one of the first focusing estimated value and the second focusing estimated value with reference to the depth of field. With this setting, it is possible to select the data given from the second focusing estimating device if a focusing accuracy in the first focusing estimating device is inferior to a focusing accuracy in the second focusing estimating device.

Moreover, the autofocus apparatus of the present invention is provided with the object dimension calculating device, the object dimension setting device and the focusing object controlling device that are
5 constructed as described above. With this construction, a focusing range can be further limited by focusing on the object concerned only when the object real dimension calculated by the object dimension calculating device is coincident with a
10 photographing target dimension set by the object dimension setting device. Further, the first focusing estimating device is made to create the estimated value in a small area, with the result that the second focusing estimating device does not necessarily create
15 the estimated value in the small area enough to decrease a resolution of the second focusing estimating device. The costs for the second focusing estimating device can be thereby restrained.

Moreover, when the autofocus apparatus of the present invention is provided with the above-
20 constructed focus area setting device, for example, the focus area of the first focusing estimating device is set smaller than the focus area of the second focusing estimating device, thereby making it feasible to
25 decrease a detection sensitivity of the imaging positional deviation with respect to the second focusing estimating device. The resolution of the

second imaging element can be thereby enhanced, and consequently the costs for the second focusing estimating device can be restrained.

Further, in another autofocus apparatus according to the present invention, with the construction described above, for instance, only a specified object (e.g., human being) can be focused on from within the photographic area by focusing on the object concerned only when the object real dimension calculated by the object dimension calculating device is coincident with the photographing target dimension set by the object dimension setting device.

A lens barrel according to the present invention is attachable to a camera body having a first focusing estimating device for creating focusing data for focusing an image on an imaging surface upon an object on the basis of a level of a frequency component selected from an electric signal obtained by an image formed on the imaging surface. Preferably, the lens barrel comprises a photographing optical system having a focus adjusting lens disposed movably, a beam splitting element for splitting light beams incident on the focus adjusting lens and emerging from the object, and a first image forming lens for forming one light beam of the light beams split by the beam splitting element into an image. The photographing optical system guides the light beam incident on the first

image forming lens and emerging from the object onto
the imaging surface. The lens barrel also comprises a
second focusing estimating device having a second image
forming lens for forming the other light beam of the
5 light beams split by the beam splitting element into an
image, at least one pair of image re-forming lenses for
respectively re-forming, into images, the light beams
emerging from the object which beams have been image-
formed by the second image forming lens, and an imaging
10 element for picking up the images obtained by at least
one pair of image re-forming lenses, the second
focusing estimating device creating an item of focusing
data for focusing the image on the imaging surface upon
the object on the basis of an imaging positional
15 deviation on the imaging element between the images
obtained by at least one pair of image re-forming
lenses. The lens barrel further comprises a moving
device for moving the focus adjusting lens on the basis
of the focusing data created by the first focusing
20 estimating device or the second focusing estimating
device.

It is preferable that the lens barrel according to
the present invention further comprises a selecting
device for selecting at least one of the first focusing
25 estimating device and the second focusing estimating
device. The moving device moves the focus adjusting
lens on the basis of the focusing data created by the

focusing estimating device selected by the selecting device.

A lens barrel according to the present invention is attachable to a camera body for generating an
5 electric signal based on an image formed in an imaging surface. Preferably, the lens barrel comprises a photographing optical system having a focus adjusting lens disposed movably, a beam splitting element for
10 splitting light beams incident on the focus adjusting lens and emerging from an object, and a first image forming lens for forming one light beam of the light beams split by the beam splitting element into an image. The photographing optical system guides the
15 light beam incident on the first image forming lens and emerging from the object onto the imaging surface. The lens barrel also comprises a first focusing estimating device for creating focusing data for focusing an image on the imaging surface upon the object on the basis of
20 a level of a frequency component selected from the electric signal. The lens barrel further comprises a second focusing estimating device having a second image forming lens for forming the other light beam of the light beams split by the beam splitting element into an image, at least one pair of image re-forming lenses for
25 respectively re-forming, into images, the light beams emerging from the object which beams have been image-formed by the second image forming lens, and an imaging

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element for picking up the images obtained by at least one pair of image re-forming lenses, the second focusing estimating device creating an item of focusing data for focusing the image on the imaging surface upon the object on the basis of an imaging positional deviation on the imaging element between the images obtained by at least one pair of image re-forming lenses. The lens barrel still further comprises a selecting device for selecting at least one of the first focusing estimating device and the second focusing estimating device, and a moving device for moving the focus adjusting lens on the basis of the focusing data created by the focusing estimating device selected by the selecting device.

15 In the present invention, it is preferable that the selecting device, if the imaging positional deviation detected by the positional deviation detecting device is under a predetermined value, selects the first focusing estimating device and, if larger than the predetermined value, selects the second focusing estimating device.

25 A lens barrel according to the present invention is attachable to a camera body containing identification data indicating whether to have a first focusing estimating device for creating an item of focusing data for focusing an image on an imaging surface upon an object on the basis of a level of a

predetermined frequency component selected from an electric signal obtained by an image formed on the imaging surface. Preferably, the lens barrel comprises a photographing optical system having a focus adjusting lens disposed movably, a beam splitting element for splitting light beams incident on the focus adjusting lens and emerging from an object, and a first image forming lens for forming one light beam of the light beams split by the beam splitting element into an image. The photographing optical system guides the light beam incident on the first image forming lens and emerging from the object onto the imaging surface. The lens barrel also comprises a second focusing estimating device having a second image forming lens for forming the other light beam of the light beams split by the beam splitting element into an image, at least one pair of image re-forming lenses for respectively re-forming, into images, the light beams emerging from the object which beams have been image-formed by the second image forming lens, and an imaging element for picking up the images obtained by at least one pair of image re-forming lenses, the second focusing estimating device creating an item of focusing data for focusing the image on the imaging surface upon the object on the basis of an imaging positional deviation on the imaging element between the images obtained by at least one pair of image re-forming lenses. The lens barrel

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further comprises a judging device for judging whether or not the camera body has the first focusing estimating device on the basis of the identification data, and a selecting device for selecting, if the
5 judging device judges that the camera body does not have the first focusing estimating device, the second focusing estimating device, and selecting, if the judging device judges that the camera body has the first focusing estimating device, at least one of the
10 first focusing estimating device and the second focusing estimating device. The lens barrel still further comprises a moving device for moving the focus adjusting lens on the basis of the focusing data created by the focusing estimating device selected by
15 the selecting device.

In the present invention, it is preferable that the selecting device, when the judging device judges that the camera body has the first focusing estimating device, selects the first focusing estimating device if
20 the imaging positional deviation detected by the positional deviation detecting device is under a predetermined value, and, if larger than the predetermined value, selects the second focusing estimating device.

25 A camera according to the present invention preferably comprises a camera body for generating an electric signal based on an image form on an imaging

surface, and a lens barrel comprising a photographing optical system having a focus adjusting lens disposed movably, a beam splitting element for splitting light beams incident on the focus adjusting lens and emerging from an object, and a first image forming lens for forming one light beam of the light beams split by the beam splitting element into an image. The photographing optical system guides the light beam incident on the first image forming lens and emerging from the object onto the imaging surface. The camera also comprises a first focusing estimating device for creating focusing data for focusing an image on the imaging surface upon the object on the basis of a level of a frequency component selected from the electric signal, and a second focusing estimating device having a second image forming lens for forming the other light beam of the light beams split by the beam splitting element into an image, at least one pair of image re-forming lenses for respectively re-forming, into images, the light beams emerging from the object which beams have been image-formed by the second image forming lens, and an imaging element for picking up the images obtained by at least one pair of image re-forming lenses, the second focusing estimating device creating an item of focusing data for focusing the image on the imaging surface upon the object on the basis of an imaging positional deviation on the imaging

element between the images obtained by at least one pair of image re-forming lenses. The camera further comprises a selecting device for selecting at least one of the first focusing estimating device and the second focusing estimating device, and a moving device for moving the focus adjusting lens on the basis of the focusing data created by the focusing estimating device selected by the selecting device. The camera body incorporates the first focusing estimating device and the selecting device, while the lens barrel incorporates the second focusing estimating device and the moving device.

A camera according to the present invention preferably comprises a camera body for generating an electric signal based on an image form on an imaging surface, and a lens barrel comprising a photographing optical system having a focus adjusting lens disposed movably, a beam splitting element for splitting light beams incident on the focus adjusting lens and emerging from an object, and a first image forming lens for forming one light beam of the light beams split by the beam splitting element into an image. The photographing optical system guides the light beam incident on the first image forming lens and emerging from the object onto the imaging surface. The camera also comprises a first focusing estimating device for creating focusing data for focusing an image on the

imaging surface upon the object on the basis of a level of a frequency component selected from the electric signal, and a second focusing estimating device having a second image forming lens for forming the other light beam of the light beams split by the beam splitting element into an image, at least one pair of image re-forming lenses for respectively re-forming, into images, the light beams emerging from the object which beams have been image-formed by the second image forming lens, and an imaging element for picking up the images obtained by at least one pair of image re-forming lenses, the second focusing estimating device creating an item of focusing data for focusing the image on the imaging surface upon the object on the basis of an imaging positional deviation on the imaging element between the images obtained by at least one pair of image re-forming lenses. The camera further comprises a selecting device for selecting at least one of the first focusing estimating device and the second focusing estimating device, and a moving device for moving the focus adjusting lens on the basis of the focusing data created by the focusing estimating device selected by the selecting device. The camera body incorporates the first focusing estimating device, while the lens barrel incorporates the second focusing estimating device, the selecting device and the moving device.

A camera according to the present invention preferably comprises a camera body for picking up an image formed on a predetermined plane, and a lens barrel comprising a photographing optical system,

5 having a focus adjusting lens disposed movably, for guiding the light beam incident on the focus adjusting lens and emerging from an object onto the predetermined plane. The camera body contains identification data indicating whether or not the camera body has a first

10 focusing estimating device for creating focusing data for focusing the image on the predetermined plane upon the object. The lens barrel further comprises a second focusing estimating device for creating the focusing data for focusing the image on the predetermined plane

15 upon the object, a judging device for judging whether or not the camera body has the first focusing estimating device on the basis of the identification data, a selecting device for selecting the second focusing estimating device when the judging device

20 judges that the camera body does not have the first focusing estimating device, and selecting at least one of the first focusing estimating device and the second focusing estimating device when the judging device judges that the camera body has the first focusing

25 estimating device, and a moving device for moving the focus adjusting lens on the basis of the focusing data created by the focusing estimating device selected by

the selecting device.

A camera according to the present invention preferably comprises a camera body for generating an electric signal based on an image formed on an imaging surface, and a lens barrel comprising a photographing
5 optical system having a focus adjusting lens disposed movably, a beam splitting element for splitting light beams incident on the focus adjusting lens and emerging from an object, and a first image forming lens for
10 forming one light beam of the light beams split by the beam splitting element into an image. The photographing optical system guides the light beam incident on the first image forming lens and emerging from the object onto the imaging surface. The camera
15 body contains identification data indicating whether or not the camera body has a first focusing estimating device for creating focusing data for focusing the image on the imaging surface upon the object on the basis of a level of a predetermined frequency component
20 selected from the electric signal. The lens barrel further comprises a second focusing estimating device having a second image forming lens for forming the other light beam of the light beams split by the beam splitting element into an image, at least one pair of
25 image re-forming lenses for respectively re-forming, into images, the light beams emerging from the object which beams have been image-formed by the second image

forming lens, and an imaging element for picking up the
images obtained by at least one pair of image re-
forming lenses, the second focusing estimating device
creating an item of focusing data for focusing the
5 image on the imaging surface upon the object on the
basis of the imaging positional deviation on the
imaging element between the images obtained by at least
one pair of image re-forming lenses. The lens barrel
further comprises a judging device for judging whether
10 or not the camera body has the first focusing
estimating device on the basis of the identification
data, and a selecting device for selecting the second
focusing estimating device when the judging device
judges that the camera body does not have the first
15 focusing estimating device, and selecting at least one
of the first focusing estimating device and the second
focusing estimating device when the judging device
judges that the camera body has the first focusing
estimating device. The lens barrel further comprises a
20 moving device for moving the focus adjusting lens on
the basis of the focusing data created by the focusing
estimating device selected by the selecting device.

A lens barrel according to the present invention
is attachable to a camera body for generating an
25 electric signal based on an image formed on an imaging
surface. Preferably, the lens barrel comprises a
photographing optical system having a focus adjusting

lens disposed movably, and an image forming lens for forming a light beam incident on the focus adjusting lens and emerging from an object into an image. The photographing optical system guides the light beam
5 incident on the image forming lens and emerging from the object onto the imaging surface. The lens barrel also comprises a focusing estimating device for creating an item of focusing data for focusing the image on the imaging surface upon the object on the
10 basis of a level of a predetermined frequency component selected from the electric signal, and a moving device for moving the focus adjusting lens on the basis of the focusing data created by the focusing estimating device.

15 A lens barrel according to the present invention is attachable to a camera body for picking up an image formed on a predetermined plane. Preferably, the lens barrel comprises a photographing optical system having a focus adjusting lens disposed movably, a beam
20 splitting element for splitting light beams incident on the focus adjusting lens and emerging from an object, and a first image forming lens for forming one light beam of the light beams split by the beam splitting element into an image. The photographing optical
25 system guides the light beam incident on the first image forming lens and emerging from the object onto the predetermined plane. The lens barrel also

comprises a focusing estimating device having a second
image forming lens for forming the other light beam of
the light beams split by the beam splitting element
into an image, at least one pair of image re-forming
5 lenses for respectively re-forming, into images, the
light beams emerging from the object which beams have
been image-formed by the second image forming lens, and
an imaging element for picking up the images obtained
by at least one pair of image re-forming lenses, the
10 focusing estimating device creating an item of focusing
data for focusing the image on the predetermined plane
upon the object on the basis of the imaging positional
deviation on the imaging element between the images
obtained by at least one pair of image re-forming
15 lenses. The lens barrel further comprises a moving
device for moving the focus adjusting lens on the basis
of the focusing data created by the focusing estimating
device.

An autofocus apparatus according to the present
20 invention preferably comprises a photographing optical
system having at least a focus adjusting lens disposed
movably and an image forming lens for forming, into an
image, light beams incident on the focus adjusting lens
and emerging from an object. The autofocus apparatus
25 also comprises a plurality of focusing estimating
devices for creating focusing data for focusing an
image formed on a predetermined plane through the

photographing optical system, upon the object. The autofocus apparatus further comprises a storage device stored with a correction value for the focusing data created by at least one of the plurality of focusing
5 estimating devices, and a correcting device for correcting, with the correction value, the focusing data corresponding to the correction value stored in the storage device. The autofocus apparatus still further comprises a selecting device for selecting at
10 least one of the plurality of focusing estimating devices, and a moving device for moving the focus adjusting lens on the basis of the focusing data created by the focusing estimating device selected by the selecting device, or the relevant corrected
15 focusing data if the relevant focusing data has been corrected by the correcting device.

An autofocus apparatus according to the present invention preferably comprises a photographing optical system having at least a focus adjusting lens disposed
20 movably, a beam splitting element for splitting light beams incident on the focus adjusting lens and emerging from an object, a first image forming lens for forming one light beam of the light beams split by the beam splitting element into an image, and a second image
25 forming lens for forming the other light beam of the light beams split by the beam splitting element into an image. The autofocus apparatus also comprises a first

It is preferable that the autofocus apparatus according to the present invention further comprises a storage controlling device for storing the storage
20 device with the data detected by the data detecting portion as the correction value when the first focus estimating portion creates the focusing data indicating that the image obtained by the first image forming lens
25 is focused on the object on the first plane.

system having at least a focus adjusting lens disposed movably, a beam splitting element for splitting light beams incident on the focus adjusting lens and emerging from an object, a first image forming lens for forming one light beam of the light beams split by the optical element into an image, and a second image forming lens for forming the other light beam of the light beams split by the beam splitting element into an image. The autofocus apparatus also comprises a first focusing estimating portion having a first imaging element for picking up the image obtained by the first image forming lens and converting it into an electric signal, a level detecting device for detecting a level of a proper frequency component from the electric signal obtained by the first imaging element, and a first data creating device for creating an item of focusing data for focusing the image on the first imaging element upon the object on the basis of the frequency component level detected by the level detecting device. The autofocus apparatus further comprises a second focusing estimating portion having an image re-forming optical system for respectively re-forming, into images, the light beams passing through portions with different pupils among the light beams for forming the image formed by the second image forming lens, a second imaging element for picking up the images obtained by the image re-forming optical system, a positional

deviation detecting device for detecting an imaging
positional deviation on the second imaging element, a
storage device stored, as a correction value, with the
imaging positional deviation detected by the positional
5 deviation detecting device when the image on the first
imaging element is focused on the object, a correcting
device for correcting, with the correction value stored
in the storage device, the imaging positional deviation
detected by the positional deviation detecting device,
10 and a second data creating device for creating an item
of focusing data for focusing the image on the first
imaging element upon the object on the basis of the
imaging positional deviation corrected by the
correcting device. The autofocus apparatus still
15 further comprises a selecting portion for selecting at
least one of the first focusing estimating portion and
the second focusing estimating portion, and a moving
device for moving the focus adjusting lens on the basis
of the focusing data created by the focusing estimating
20 device selected by the selecting portion.

The autofocus apparatus according to the present
invention preferably further comprises a storage
controlling device for storing the storage device with
the imaging positional deviation detected by the
25 positional deviation detecting device as the correction
value when the first focus estimating portion creates
the focusing data indicating that the image on the

first imaging element is focused on the object.

Provided further are the storage device stored with the correction value for the focusing data created by at least one of the plurality of focusing estimating devices, and the correcting device for correcting, with a correction value, the focusing data corresponding to the relevant correction value stored in the storage device. Therefore, for example, as one of the plurality of focusing estimating devices, as in the case of the image deviation type focusing estimating device explained in the prior art, the light beams are diverged from the photographing optical system for forming the image on the imaging surface of the camera body and form an image in a different position from the imaging surface, and whether or not the image on the imaging surface is focused on is estimated by use of the above image. Even in the case of using this method, the storage device stores, as a correction value, a deviation in the optical positional relationship between the imaging surface of the camera body and the surface formed with the image for estimating the focusing. The focusing data of the corresponding focusing estimating device is corrected by use of the above stored correction value, whereby a focusing accuracy is prevented from declining when using the relevant focusing estimating device.

An autofocus apparatus according to the present

invention preferably comprises a photographing optical system having at least a focus adjusting lens disposed movably, and an image forming lens so movably disposed as to form light beams incident on the focus adjusting
5 lens and emerging from an object into an image. The autofocus apparatus also comprises a plurality of focusing estimating devices for creating focusing data for focusing an image formed on a predetermined plane through the photographing optical system upon the
10 object, and a position detecting device for detecting position data of the image forming lens. The autofocus apparatus further comprises a correcting device for correcting the focusing data created by at least one of the plurality of focusing estimating devices on the
15 basis of the data about the position detected by the position detecting device, a selecting device for selecting at least one of the plurality of focusing estimating devices, and a moving device for moving the focus adjusting lens on the basis of the focusing data
20 created by the focusing estimating device selected by the selecting device, or the relevant corrected focusing data if the relevant focusing data has been corrected by the correcting device.

An autofocus apparatus according to the present
25 invention preferably comprises a photographing optical system having at least a focus adjusting lens disposed movably, a beam splitting element for splitting light

beams incident on the focus adjusting lens and emerging from an object, a first image forming lens for forming one light beam of the light beams split by the optical element into an image, and a second image forming lens for forming the other light beam of the light beams split by the beam splitting element into an image. The autofocus apparatus also comprises a first focusing estimating portion for creating the focusing data for focusing the image obtained by the first image forming lens upon the object on a first plane on the basis of the image obtained by the first image forming lens. The autofocus apparatus further comprises a second focusing estimating portion having a data detecting device for detecting the data for focusing the image obtained by the second image forming lens upon the object on a second plane, a position detecting device for detecting the position data of the first image forming lens, a correcting device for correcting the data detected by the data detecting device on the basis of an item of data corresponding to the data about the position of the first image forming lens that has been detected by the position detecting device, which item of data is obtained from a relationship between the position of the first image forming lens and the data detected by the data detecting device when the image on the first plane is focused on the object, and a data creating device for creating focusing data for focusing

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the image obtained by the first image forming lens upon the object on the first plane. The autofocus apparatus still further comprises a selecting portion for selecting at least one of the first focusing estimating
5 portion and the second focusing estimating portion, and a moving device for moving the focus adjusting lens on the basis of the focusing data created by the focusing estimating device selected by the selecting portion.

An autofocus apparatus according to the present
10 invention preferably comprises a photographing optical system having at least a focus adjusting lens disposed movably, a beam splitting element for splitting light beams incident on the focus adjusting lens and emerging from an object, a first image forming lens for forming
15 one light beam of the light beams split by the optical element into an image, and a second image forming lens for forming the other light beam of the light beams split by the beam splitting element into an image. The autofocus apparatus also comprises a first focusing
20 estimating portion for picking up the image obtained by the first image forming lens and converting it into an electric signal, a level detecting device for detecting a level of a proper frequency component from the electric signal obtained by the first imaging element,
25 and a first data creating device for creating an item of focusing data for focusing the image on the first imaging element upon the object on the basis of the

frequency component level detected by the level
detecting device. The autofocus apparatus further
comprises a second focusing estimating portion having
an image re-forming optical system for respectively re-
forming, into images, the light beams passing through
portions with different pupils among the light beams
for forming the image formed by the second image
forming lens, a second imaging element for picking up
the images obtained by the image re-forming optical
system, a positional deviation detecting device for
detecting an imaging positional deviation on the second
imaging element, a position detecting device for
detecting position data of the first image forming
lens, a correcting device for correcting imaging
positional deviation detected by the data detecting
device on the basis of an imaging positional deviation
corresponding to the data about the position of the
first image forming lens that has been detected by the
position detecting device, which imaging positional
deviation is obtained from a relationship between the
position of the first image forming lens and the
imaging positional deviation detected by the positional
deviation detecting device when the image on the first
imaging element is focused on the object, and a second
data creating device for creating focusing data for
focusing the image on the first imaging element upon
the object on the basis of the imaging positional

deviation corrected by the correcting device. The autofocus apparatus still further comprises a selecting portion for selecting at least one of the first focusing estimating portion and the second focusing estimating portion, and a moving device for moving the focus adjusting lens on the basis of the focusing data created by the focusing estimating device selected by the selecting portion.

An autofocus apparatus according to the present invention preferably comprises a photographing optical system having at least a focus adjusting lens disposed movably, a beam splitting element for splitting light beams incident on the focus adjusting lens and emerging from an object, a first image forming lens so disposed movably as to form one light beam of the light beams split by the optical element into an image, and a second image forming lens for forming the other light beam of the light beams split by the beam splitting element into an image. The autofocus apparatus also comprises a first focusing estimating portion having a first imaging element for picking up the image obtained by the first image forming lens and converting it into an electric signal, a level detecting device for detecting a level of a proper frequency component from the electric signal obtained by the first imaging element, and a first data creating device for creating an item of focusing data for focusing the image on the

first imaging element upon the object on the basis of the frequency component level detected by the level detecting device. The autofocus apparatus further comprises a second focusing estimating portion having

5 an image re-forming optical system for respectively re-forming, into images, the light beams passing through portions with different pupils among the light beams for forming the image formed by the second image forming lens, a second imaging element for picking up

10 the images obtained by the image re-forming optical system, a positional deviation detecting device for detecting an imaging positional deviation on the second imaging element, a correcting device for correcting a position of the image forming lens on the basis of an

15 item of position data of the second image forming lens that corresponds to data about the position, detected by the position detecting device, of the first image forming lens, which item of position data is obtained from such a relationship between the position of the

20 first image forming lens and the position of the second image forming lens that the imaging positional deviation on the second imaging element disappears when the image on the first imaging element is focused on, and a second data creating device for creating focusing

25 data for focusing the image on the first imaging element upon the object. The autofocus apparatus still further comprises a selecting portion for selecting at

least one of the first focusing estimating portion and the second focusing estimating portion, and a moving device for moving the focus adjusting lens on the basis of the focusing data created by the focusing estimating device selected by the selecting portion.

According to the present invention, there are provided the plurality of focusing estimating devices for creating the focusing data for focusing the image formed on the predetermined plane through the photographing optical system upon the object. The selecting device selects at least one of these focusing estimating devices. The focus adjusting lens is moved based on the focusing data created by the selected focusing estimating device. Hence, according to the present invention, for instance, the crest climbing type focusing estimating device and the image deviation type focusing estimating device, which have been described in the prior art, are provided as the focusing estimating devices. To start with, the selecting device is set so that the image on the predetermined plane is roughly focused on by use of the image deviation type focusing estimating device, and thereafter the image on the predetermined plane is finely focused on by use of the focusing data of the crest climbing type focusing estimating device. It is therefore possible to effect the focusing quickly with the high precision.

Furthermore, according to the present invention, there are provided the position detecting device for detecting the position data of the image forming lens, and the correcting device for correcting the focusing data to be corrected, which data is created by the focusing estimating device, on the basis of the position data of the image forming lens that has been detected by the position detecting device. Therefore, for example, as one of the plurality of focusing estimating devices, as in the case of the image deviation type focusing estimating device explained in the prior art, the light beams are diverged from the photographing optical system for forming the image on the imaging surface of the camera body and form an image in a different position from the imaging surface, and whether or not the image on the imaging surface is focused on is estimated by use of the above image. Even in the case of using this method, the position data of the image forming lens is detected, and the deviation in the optical positional relationship between the imaging surface of the camera body and the surface formed with the image for estimating the focusing, is obtained from the above position data. Then, with the thus obtained deviation serving as the correction value, the focusing data of the corresponding focusing estimating device is corrected, thereby making it possible to prevent the decline in

the focusing accuracy when using the relevant focusing estimating device.

BRIEF DESCRIPTION OF THE DRAWINGS

5 Other objects and advantages of the present invention will become apparent during the following discussion in conjunction with the accompanying drawings, in which:

10 Fig. 1 is a schematic block diagram illustrating a crest climbing type autofocus apparatus;

 Fig. 2 is an explanatory diagram showing a relationship between a level of a high frequency of a picture signal and a position of a focus adjusting lens;

15 Fig. 3 is an explanatory diagram of a principle of an image deviation type autofocus apparatus, showing a light path when in a focused state;

20 Fig. 4 is an explanatory diagram showing positions of images to be picked up by two line sensors 99a, 99b in Fig. 3;

 Fig. 5 is an explanatory diagram of the principle of the image deviation type autofocus apparatus, showing the light path when in a defocused state;

25 Fig. 6 is an explanatory diagram illustrating the images picked up by the two line sensors 99a, 99b in Fig. 5;

 Fig. 7 is an explanatory diagram of the principle

of the image deviation type autofocus apparatus,
showing the light path when in the defocused state;

Fig. 8 is an explanatory diagram illustrating the
positions of the images picked up by the two line
5 sensors 99a, 99b in Fig. 7;

Fig. 9 is a schematic block diagram of a video
camera to which a prior art crest climbing type
autofocus apparatus is applied;

Fig. 10 is a schematic block diagram illustrating
10 an autofocus apparatus in a first embodiment of the
present invention;

Fig. 11 is a diagram showing a modified example of
the first embodiment of the present invention;

Fig. 12 is a schematic block diagram illustrating
15 the autofocus apparatus in a second embodiment of the
present invention;

Fig. 13 is a diagram showing a modified example of
the second embodiment of the present invention;

Fig. 14 is a diagram showing a modified example of
20 the second embodiment of the present invention;

Fig. 15 is a schematic block diagram illustrating
the autofocus apparatus in a third embodiment of the
present invention;

Fig. 16 is an explanatory diagram showing a
25 relationship between a focal length of a photographing
optical system, a distance from the photographing
optical system to an object, a dimension of the object

on an imaging element, and a real dimension of the object;

Fig. 17 is a diagram showing one example of an object dimension setting device used in the third
5 embodiment;

Fig. 18 is a diagram showing one example of the object dimension setting device used in the third embodiment;

Fig. 19 is an explanatory diagram showing a case
10 where a plurality of distance measuring portions of a second focusing estimating portion are provided;

Fig. 20 is a schematic block diagram illustrating the autofocus apparatus in a fourth embodiment of the present invention;

Fig. 21 is an explanatory diagram showing a focus
15 area of a first focusing estimating portion and a focus area of the second focusing estimating portion;

Fig. 22 is a diagram showing one example of a focus area inputting device used in the fourth
20 embodiment;

Fig. 23 is an explanatory diagram showing how a focus area setting device operates;

Fig. 24 is an explanatory diagram showing how the focus area setting device operates;

Fig. 25 is a diagram showing one example of the focus area inputting device used in the fourth
25 embodiment;

Fig. 26 is a diagram showing one example of the focus area inputting device used in the fourth embodiment;

5 Fig. 27 is an explanatory diagram showing a case where a plurality of focus areas of the second focusing estimating portion are provided;

Fig. 28 is a schematic block diagram illustrating the autofocus apparatus in a fifth embodiment of the present invention;

10 Fig. 29 is a schematic block diagram illustrating a TV camera in a sixth embodiment of the present invention;

15 Fig. 30 is an explanatory flowchart showing how the TV camera shown in Fig. 29 performs an autofocus operation;

Fig. 31 is an explanatory diagram of a principle of an image deviation type autofocus system, showing the light path when in a focused state;

20 Fig. 32 is an explanatory diagram showing positions of images picked up by the two line sensors in Fig. 31;

Fig. 33 is an explanatory diagram of the principle of the image deviation type autofocus system, showing the light path when in a defocused state;

25 Fig. 34 is an explanatory diagram illustrating the positions of the images picked up by the two line sensors in Fig. 33;

Fig. 35 is an explanatory diagram of the principle of the image deviation type autofocus system, showing the light path when in a defocused state;

5 Fig. 36 is an explanatory diagram showing the positions of the images picked up by the two line sensors in Fig. 35;

Fig. 37 is a schematic block diagram illustrating the TV camera in a seventh embodiment of the present invention;

10 Fig. 38 is a schematic block diagram illustrating the TV camera in an eighth embodiment of the present invention;

Fig. 39 is a schematic block diagram illustrating the TV camera in a ninth embodiment of the present
15 invention;

Fig. 40 is a schematic block diagram illustrating the TV camera in a tenth embodiment of the present invention;

Fig. 41 is a schematic block diagram illustrating the TV camera in an eleventh embodiment of the present
20 invention;

Fig. 42 is an explanatory flowchart showing the operation of the autofocus apparatus illustrated in Fig. 41;

25 Fig. 43 is an explanatory flowchart showing an operation of the first focusing estimating portion illustrated in Fig. 41;

Fig. 44 is an explanatory flowchart showing an operation of the second focusing estimating portion illustrated in Fig. 41;

5 Fig. 45 is an explanatory flowchart showing an operation of a defocus storage device shown in Fig. 41;

Fig. 46 is a schematic block diagram illustrating the autofocus apparatus in a twelfth embodiment of the present invention;

10 Fig. 47 is an explanatory flowchart showing the operation of the autofocus apparatus illustrated in Fig. 46;

Fig. 48 is an explanatory flowchart showing the operation of the first focusing estimating portion illustrated in Fig. 46;

15 Fig. 49 is an explanatory flowchart showing the operation of the second focusing estimating portion illustrated in Fig. 46;

20 Fig. 50 is a schematic block diagram showing the autofocus apparatus in a thirteenth embodiment of the present invention; and

Fig. 51 is an explanatory diagram showing a relationship between a level of a high frequency component of a picture signal and a focus adjusting lens.

25

DESCRIPTION OF THE PREFERRED EMBODIMENTS

One embodiment of the present invention will

hereinafter be described with reference to the drawings.

Fig. 10 is a schematic block diagram illustrating an autofocus apparatus in one embodiment of the present invention.

The autofocus apparatus in this embodiment includes, as illustrated in Fig. 10, a photographing optical system 1, a first focus estimating part 2, a second focusing estimating part 3, a focusing method selecting device 4, a motor 5, and a motor driving device 6.

The photographing optical system 1 is constructed of four lens units such as a focus adjusting lens 11, a variable magnification lens 12, a correcting lens 13, and an image forming lens 14. This construction is typical of a zoom lens for a TV camera. In the photographing optical system 1 used in this embodiment, an optical element (e.g., a beam splitter) 15 for splitting light beams and a stop 16 are interposed in between the correcting lens 13 and the image forming lens 14. Note that the optical element 15 is disposed anterior to the stop 16 so that the light beams can be transmitted to the second focusing estimating part 3 irrespective of an aperture quantity of an aperture stop of the photographing optical system 1 in this embodiment.

The first focusing estimating part 2 estimates

point A, and this level reaches a peak when the image on the imaging element 21 is focused on. Subsequently, the focusing estimated value creating device 23 selects a proper high frequency component in consideration of
5 an S/N ratio of the picture signal as well as of an imaging performance of the photographing optical system 1, out of the picture signal obtained by the picture signal making device 22. Then, the focusing estimated value creating device 23 creates a focusing estimated
10 value by monitoring a level of this frequency component at a predetermined sampling interval. For example, when the level of the selected frequency component rises, it is estimated that the focus adjusting lens 11 is moving in such a direction as to approach a focusing
15 point. Further, when the level of the selected frequency component lowers, it is estimated that the focus adjusting lens 11 is moving in such a direction as to get away from the focusing point. Then, when the level of the selected frequency component exists within
20 a predetermined range (shown by, e.g., ΔV in Fig. 2) from the peak value, it is estimated that the image on the imaging element 21 is focused on.

The second focusing estimating part 3 estimates focusing by a so-called image deviation method. The
25 second focusing estimating part 3 comprises a mirror 31 for reflecting the light beam split by the optical element 15, toward a predetermined direction, and an

image forming lens 32 for forming light beams incident via the mirror 31 into a conjugate image. The second focusing estimating part 3 further comprises image re-forming lenses 33a, 33b for forming some of the light beams image formed by the image forming lens 32, again into images, line sensors 34a, 34b for respectively picking up the images formed by the image re-forming lenses 33a, 33b and converting them into electric signals, an image processing device 35, and a focusing estimation selecting device 36.

The image forming lens 32 is disposed so that the light beams incident via the mirror 31 are image-formed on a predetermined focal surface 37 when the image on the imaging element 21 is focused on. The image re-forming lenses 33a, 33b are disposed in positions substantially symmetric with respect to the optical axis of the image forming lens 32. More specifically, the image re-forming lenses 33a, 33b are so disposed as to individually re-form the images of the light beams passing through portions having different pupils in the optical system consisting of the focus adjusting lens 11, the variable magnification lens 12, the correcting lens 13 and the image forming lens 32, among the light beams for forming the image formed by the image forming lens 32. The line sensors 34a, 34b are disposed in the positions substantially symmetric with respect to the optical axis of the image forming lens 32 and on a

predetermined focal surface of the image re-forming lenses 33a, 33b corresponding to each other. The image processing device 35 executes the image processing based on the electric signals transmitted respectively
5 from the line sensors 34a, 34b. The focusing estimated value creating device 36 creates an item of data (a second focusing estimated value) for focusing the image formed on the imaging element 21 on the basis of the signal transmitted from the image processing device 35.

10 Next, the second focusing estimated value created by the focusing estimated value creating device 36 will be explained. As stated in the prior art, when the light beams traveling through the image forming lens 32 are focused on the predetermined focal surface 37, some
15 of the light beams are again formed on the line sensors 34a, 34b by the image re-forming lenses 33a, 33b. Hence, if focused on the predetermined focal surface 37, the images picked up by the two line sensors 33a, 33b are formed in substantially coincident positions on
20 the line sensors. On the other hand, when the light beams passing through the image forming lens 32 are focused on anterior to the predetermined focal surface 37 (which is a so-called rear focus state), there must be a deviation between the images picked up by the two
25 line sensors 34a, 34b. Also, when the light beams passing through the image forming lens 32 are focused on posterior to the predetermined focal surface 37

(which is a so-called front focus state), there must be a deviation in a direction opposite to the one in the rear focus state between the images picked up by the two line sensors 34a, 34b. Then, the focusing
5 estimated value creating device 36 detects a deviation quantity and a deviating direction between the images picked up by the line sensors 34a, 34b, and, based on the data thereof, creates a moving direction and a moving quantity, or a defocus quantity and a defocus
10 direction (a second focusing estimated value) of the focus adjusting lens 11, which are needed for focusing on the predetermined focal surface 37. Note that the second focusing estimated value is created at the interval of a predetermined time in consideration of a
15 processing speed, etc. of the image processing device 35.

The focusing method selecting device 4 selects at least one of the first focusing estimated value created by the first focusing estimating part 2 and the second
20 focusing estimated value created by the second focusing estimating part 3. In accordance with this embodiment, referring first to the second focusing estimated value, if the required-for-focusing moving quantity of the focus adjusting lens 11 is larger than a threshold
25 value, the second focusing estimated value is set to be selected. Whereas if smaller than the threshold value, the first focusing estimated value is set to be

referring to the second focusing estimated value,
judges whether or not the required-for-focusing moving
quantity or defocus quantity of the focus adjusting
lens 11 is larger than the threshold value. Then, if
5 the required-for-focusing moving quantity or defocus
quantity of the focus adjusting lens 11 is larger than
the threshold value, the second focusing estimated
value is selected. Whereas if smaller than the
threshold value, the first focusing estimated value is
10 selected.

Next, the motor driving device 6 drives the motor
based on the focusing estimated value selected by the
focusing method selecting device 4. For instance, if
the second focusing estimated value is selected by the
15 focusing method selecting device 4, the motor driving
device 6 drives the motor 5 to move the focus driving
lens 11 in the moving direction with the moving
quantity that are indicated by the selected second
focusing estimated value. Further, for example, if the
20 first focusing estimated value is selected by the
focusing method selecting device 4, and when estimating
that the focus adjusting lens 11 is moving in such a
direction as to approach the focusing point, the motor
driving device 6 drives the motor 5 to keep a rotating
25 direction of the motor 5 as it is. Moreover, when
estimating that the focus adjusting lens 11 is moving
in such a direction as to get away from the focusing

point, the motor driving device 6 drives the motor 5 to reverse the rotating direction of the motor 5.

The motor driving device 6 continues to drive the motor 5 till it is estimated that the first focusing
5 estimated value is selected by the focusing method selecting device 4 and a content of the first focusing estimated value indicates an in-focus state. The image on the imaging element 21 is thereby focused on.

In accordance with the first embodiment of the
10 present invention, the first focusing estimating part 2 creates the first focusing estimated value by use of the so-called crest climbing method, and the second focusing estimating part 3 creates the second focusing estimated value by use of the so-called image deviation
15 method. Further, the focusing method selecting device 4 selects the second focusing estimated value when the second focusing estimated value is larger than the threshold value, and selects the first focusing estimated value when smaller than the threshold value.
20 Then, the motor driving device 6, based on the focusing estimated value selected by the focusing method selecting device 4, drives the motor 5 to move the focus adjusting lens 11. With this operation, to begin with, the image on the imaging element 21 is roughly
25 focused on by use of the second focusing estimated value, and thereafter the image on the imaging element 21 is finely focused on by use of the first focusing

estimated value. Accordingly, in accordance with the first embodiment, the image on the imaging element 21 can be focused on quickly with a high accuracy. Further, the high accuracy is not required of the
5 second focusing estimating part 3 using the image deviation method, and hence the costs can be restrained from rising.

Moreover, in the first embodiment of the present invention, a focal length of the optical system for
10 forming images for detecting the image deviation on the line sensors 34a, 34b in the second focusing estimating part 3, is a synthetic focal length of the focus adjusting lens 11, the variable magnification lens 12, the correcting lens 13 and the image forming lens 32.
15 On the other hand, a focal length of the optical system for forming an image for the picture signal on the imaging element 21, is a synthetic focal length of the focus adjusting lens 11, the variable magnification lens 12, the correcting lens 13 and the image forming
20 lens 14. Therefore, the focal lengths of the optical system for forming the images for detecting the image deviation and of the optical system for forming the image for the picture signal, are varied by changing configurations of the image forming lenses 14 and 32,
25 videlicet, the sizes of the images formed respectively by the individual optical systems can be changed. For instance, the image forming lens 32 is constructed to

enlarge the images for detecting the image deviation by increasing the focal length of the optical system for forming the images for detecting the image deviation, whereby pixel pitches of the lines sensors 34a, 34b
5 become finer relatively to the above images. Hence, it is feasible to focus even a minute object. Further, for example, the image forming lens 32 is constructed to diminish the images for detecting the image deviation by shortening the focal length of the optical
10 system for forming the images for detecting the image deviation, whereby sizes of these images become smaller relatively to the line sensors 34a, 34b. Therefore, it is possible to detect a larger quantity of image deviation. Even if the focus adjusting lens is
15 positioned far from the focusing point (which is a so-called largely defocused state), the focusing point can be thereby quickly detected. Also, the apparatus can be downsized.

By the way, in the image deviation type autofocus
20 apparatus used for a generally commercially available still camera, etc., the image deviation is detected by use of an image in the vicinity of the center among the images formed by the photographing optical system. Accordingly, in this image deviation type autofocus
25 apparatus, the focusing can be attained only in the vicinity of the center of an area (hereinafter also referred to as a photographic area) to be photographed

by the photographing optical system. It is because the sizes of the line sensor and of the image re-forming lens employed for detecting the image deviation are restricted due to problems in terms of a size of the camera body and costs thereof, etc.. Contrastingly in the crest climbing type autofocus apparatus used for the video camera, the focusing is effected by use of the images on the imaging element, and therefore a focus area can be changed comparatively easily.

Herein, the focus area is an area where the data for focusing is created within the photographic area. In this embodiment, the focus area corresponds to the area where the data for focusing the image on the relevant area on a corresponding object in the area on the imaging element 21. Hence, when the general image deviation type autofocus apparatus is employed for the second focusing estimating part 3, as illustrated in Fig. 11, it is preferable that a focus area selecting device 70 for selecting a position of the focus area be provided. Then, in the focusing method selecting device 4, only when the focus area selecting device 70 selects the center of the photographic area as a focus area, at least one of the first focusing estimated value and the second focusing estimated value is selected in the procedures stated in this embodiment, and it is preferable that only the first focusing estimated value be selected when a portion other than

the center in the photographic area is selected as the focus area by the focus area selecting device 70. With this operation, it is feasible to focus the image corresponding to the object existing in the plurality of areas within the photographic area, among the images on the first imaging element 21.

Further, in recent years, there have been developed some of the image deviation type autofocus apparatuses, which are capable of setting the focus area in the plurality of portions within the photographic area. This may correspond to, e.g., a multi-area focus detecting apparatus disclosed in Japanese Patent Laid-Open Application No. 6-308379. In those apparatuses, four or more (even-numbered) pieces of line sensors and image re-forming lenses are provided in the image deviation type autofocus apparatus illustrated in Fig. 3 in the statement of the prior art, and images of a plurality of portions are taken out of the images formed by the image forming optical system, thereby detecting a deviation of each of the images. If the above autofocus apparatus is used for the second focusing estimating part 3, it is possible to employ the crest climbing type and the image deviation type in combination to focus the image corresponding to the object existing in the relevant portion with respect to the plurality of portions within the photographic area.

Note that the focusing method selecting device 4 in the first embodiment of the present invention has been explained so far by way of the device for selecting the first focusing estimated value when the second focusing estimated value created by the second focusing estimating part 3 is smaller than the threshold value, and selecting the second focusing estimated value when larger than the threshold value. The present invention is not, however, limited to this.

10 The focusing method selecting device may, if, for example, any one of the first and second focusing estimated values is useless, select the other estimated value. Herein, "being useless" implies such a case that the image on the imaging element 21 can not be

15 focused on with that estimated value. It is because there must be a case where the focusing point can not be detected depending on the object on account of the fact that the crest climbing type and the image deviation type have their principles absolutely

20 different from each other.

In the first focusing estimating part 2 adopting the crest climbing method, the focusing point is detected with reference to the level of the high frequency component of the picture signal. Therefore,

25 if the object is, e.g., dark, an S/N ratio of the picture signal declines enough not to perform the focusing with a high precision. Further, when the

object is on the movement, it might happen that the peak of the high frequency component level can not be detected however long the time may elapse. In such a case, the focusing method selecting apparatus judges
5 that the first focusing estimated value is useless and therefore selects the second focusing estimated value. On the other hand, in the second focusing estimating part 3 adopting the image deviation method, the focusing point is detected based on a deviating
10 direction and a deviation quantity between the images picked up respectively by the line sensors 34a, 34b, and hence, if the object has a streak pattern, it might happen that a plurality of image deviation quantities are detected. In such a case, the focusing method
15 selecting device judges that the second focusing estimated value is useless, and therefore selects the first focusing estimated value. Thus, if any one of the first and second focusing estimated values is useless, the other estimated value is selected, thereby
20 ensuring the focusing on the object.

Next, a second embodiment of the present invention will be described with reference to the drawings.

Fig. 12 is a schematic block diagram illustrating the autofocus apparatus in the second embodiment of the
25 present invention. Note that the elements having the same functions as those in the first embodiment shown in Fig. 10 are marked with the like or corresponding

numerals in the second embodiment of the present invention, and the detailed explanations thereof are omitted.

5 A different point of the autofocus apparatus in the second embodiment shown in Fig. 12 from the first embodiment shown in Fig. 10, is that a focusing method selecting device 4a is employed in place of the focusing method selecting device 4, and that an aperture value detecting device 80 for detecting an
10 aperture value of the stop 16 of the photographing optical system 1. Other configurations are basically the same as those in the first embodiment.

A difference of the focusing method selecting device 4a from the focusing method selecting device 4
15 used in the first embodiment, is that when the aperture value sent from the aperture value detecting device 80 is under a predetermined threshold value, the second focusing estimated value is selected irrespective of whether or not the required-for-focusing moving
20 quantity, obtained from the second focusing estimated value, of the focus adjusting lens 11 is larger than the threshold value. The following is an elucidation of the reason why the aperture value is referred to for selecting the focusing method. When the stop 16 of the
25 photographing optical system 1 is stopped down, a depth of field becomes larger, and, with this larger depth of field, a crest of the high frequency component level of

the picture signal obtained by the imaging element 21 becomes gentle. This implies an enlargement of a range Δd of the position of the focus adjusting lens 11 versus a level range ΔV in which to be judged as an in-focus state in Fig. 2. On the other hand, the stop does not transmit the light beams used for the second focusing estimating part 3, and therefore the required-for-focusing moving quantity, obtained from the second focusing estimated value, of the focus adjusting lens 11 undergoes no influence by the stop. Accordingly, it might be considered that the focusing accuracy in the first focusing estimating part 3 adopting the crest climbing method is inferior to the focusing accuracy in the second focusing estimating part 3 adopting the image deviation method, depending on the aperture value (a degree of stop-down). Then, the focusing method selecting device 4a in the second embodiment selects the second focusing estimated value when the aperture value is under the predetermined threshold value regardless of the required-for-focusing moving quantity, obtained from the second focusing estimated value, of the focus adjusting lens 11. Others are the same as those in the focusing method selecting device 4 employed in the first embodiment.

In accordance with the second embodiment of the present invention, the aperture value of the photographing optical system 1 is referred to for

selecting the focusing method, and hence, upon the
stop-down of the stop 16, if the focusing accuracy in
the first focusing estimating part 2 adopting the crest
climbing method is inferior to the focusing accuracy in
5 the second focusing estimating part 3 adopting the
image deviation method, the second focusing estimated
value can be selected. The optimal focusing method in
terms of the focusing accuracy and the focusing speed
can be thereby selected.

10 Incidentally, the second embodiment has been
explained so far by way of the one requiring the
reference to the aperture value of the photographing
optical system 1 on the occasion of the selection of
the focusing method. The present invention is not,
15 however, confined to this, and there may be referred to
other factors exerting influences upon the depth of
field.

Fig. 13 is a diagram showing a modification of the
second embodiment. In the autofocus apparatus
20 illustrated in Fig. 13, positions of the focus
adjusting lens 11 and of the variable magnification
lens 12 are also referred to in addition to the
aperture value of the stop 16. This is a consideration
that there exists an optical system with a depth of
25 field, i.e., an image forming performance largely
changed depending on the position of the variable
magnification lens 12 as well as on the position of the

focus adjusting lens 11. A focusing method selecting device 4b refers to an aperture value of the stop 16 that is transmitted from an aperture value detecting device 8, a position of the variable magnification lens 12 that is transmitted from a variable magnification lens position detecting device 81, and a position of the focus adjusting lens 11 that is transmitted from a focus adjusting lens position detecting device 82. The focusing method selecting device 4b then reads an image forming performance corresponding to those values from an image forming performance storage device 83. Subsequently, when judging from the thus read image forming performance that the focusing accuracy in the first focusing estimating part 2 adopting the crest climbing method is inferior to the focusing accuracy in the second focusing estimating part 3 adopting the image deviation method, the second focusing estimated value is selected irrespective of the required-for-focusing moving quantity, obtained from the second focusing estimated value, of the focus adjusting lens 11.

Fig. 14 is a diagram showing another modification of the second embodiment. In the autofocus apparatus illustrated in Fig. 14, there is further referred to kinds of attached optical accessories. Herein, the optical accessories include converters such as a tele-converter and a wide converter, attachments such as a

wide attachment and a fish-eye attachment, filters,
close-up lenses, and extenders, which are attached to
the photographing optical system 1. Even when those
optical attachments are attached thereto, the depth of
5 field, viz., the image forming performance largely
varies depending upon the kinds thereof as the case may
be. Then, the focusing method selecting device 4c
refers to existence and non-existence and kinds of the
optical accessories, which are transmitted from an
10 optical accessory attached state detecting device 84 in
addition to the aperture value of the stop 16, and the
positions of the variable magnification lens 12 and of
the focus adjusting lens 11, and reads the image
forming performance corresponding to these values from
15 the image forming performance storage device 83a.
Then, the estimated value is selected by the same
method as that of the focusing method selecting device
4b of the autofocus apparatus shown in Fig. 13. Note
that the kinds of the optical accessories can be
20 determined by providing the optical accessories with
identification data.

Next, a third embodiment of the present invention
will be discussed with reference to the drawings.

Fig. 15 is a schematic block diagram illustrating
25 the autofocus apparatus in the third embodiment of the
present invention. Fig. 16 is an explanatory diagram
showing a relationship between a focal length of the

photographing optical system, a distance from the photographing optical system to the object, a dimension of the object on the imaging element, and a real dimension of the object. Fig. 17 is a diagram showing one example of an object dimension setting device used in the third embodiment. Note that the elements having the same functions as those in the first embodiment shown in Fig. 10 are marked with the like or corresponding numerals in the third embodiment of the present invention, and the detailed explanations thereof are omitted.

A different point of the autofocus apparatus in the third embodiment illustrated in Fig. 15 from the first embodiment shown in Fig. 10, is that there are provided an object dimension setting device 71, an object dimension calculating device 72, a focusing object controlling device 73, a focus adjusting lens encoder 74 for detecting a position of the focus adjusting lens 11, and a variable magnification lens encoder 75 for detecting a position of the variable magnification lens 12. Other configurations are basically the same as those in the first embodiment.

The object dimension setting device 71 sets a dimension (e.g., lengthwise size x crosswise size) of the object to be focused on (focusing object) with inputting by the photographer or the like. In the embodiment illustrated in Fig. 17, a pointer 71b on a

knob 71a consisting of a rotary type variable resistor is set to an arbitrary value of a scale 71c, thus setting this value to a dimension of the focusing object. Herein, the value of the scale 71c represents a crosswise size of the focusing object. The object dimension setting device 71 outputs, to the focusing object controlling device 73, a resistance value of the knob 71a, i.e., a signal corresponding to the value of the scale 71c which value is pointed by the pointer 71b on the knob 71a. Note that a slide type variable resistor and a multi-stage switch or an encoder, etc. may also be employed as a substitute for the knob 71a consisting of the rotary type variable resistor in Fig. 17. Further, this dimension may be displayed on a finder of the video camera or recorded in a record picture so that the photographer is able to grasp the dimension of the focusing object which has been set by himself or herself.

The object dimension calculating device 72 calculates the real dimension of the object on the basis of a distance from an image-side principal point of the photographing optical system 1, a distance from an object-side principal point of the photographing optical system 1, and a dimension of the object on the imaging element 21. Referring to Fig. 16, the real dimensions Y_1 and Y_2 of the objects Z_1 , Z_2 are expressed by the following formulae:

$$Y_1 = a_1 \times y_1 \div b_1$$

$$Y_2 = a_2 \times y_2 \div b_2$$

where b_1 , b_2 are the distances from the image side principal point H' of the photographing optical system 1 to the image surface, a_1 , a_2 are the distances from the object-side principal point H of the photographing optical system 1 to the objects Z_1 , Z_2 , and y_1 , y_2 are the dimensions of the objects Z_1 , Z_2 on the imaging element 21.

10 In the photographing optical system 1 in the third embodiment, the distances b_1 , b_2 from the image side principal point H' of the photographing optical system 1 to the image surface are obtained based on data about a position of the variable magnification lens 12 which
15 position is detected by the variable magnification lens encoder 75.

Further, the distances a_1 , a_2 from the photographing optical system 1 to the objects Z_1 , Z_2 are calculated based on a deviating direction and a
20 deviation quantity (a second focusing estimated value) in terms of imaging positions between the images picked up respectively by the line sensors 33a, 33b in the second focusing estimating part 3, and on data about a position of the focus adjusting lens 11 which position
25 is detected by the focus adjusting lens encoder 74.

Note that if the object on the imaging element 21 is in a state approximate to the in-focus state, the distance

from the object-side principal point of the
photographing optical system can be obtained based on
the position of the focus adjusting lens 11. The third
embodiment is, however, constructed such that the
5 distance from the photographing optical system 1 to the
object can be obtained even in a defocused state of the
object on the imaging element 21 by use of the second
focusing estimated value created by the image deviation
method and the positional data of the focus adjusting
10 lens 11.

Moreover, the dimensions of the objects Z_1 , Z_2 on
the imaging element 21 can be obtained by executing
proper image processing on the image data of the
imaging element 21. For instance, the dimensions of
15 the objects Z_1 , Z_2 on the imaging element 21 can be
acquired by emphasizing the object out by using color
signals of the image data and binarizing the image or
by executing a process such as detecting an outline and
so forth. Furthermore, if the object on the imaging
20 element 21 is in the state approximate to the in-focus
state, the dimension of the object on the imaging
element 21 can be obtained by recognizing that a
portion, with a large variation in contrast, of the
picture signal generated by the picture signal making
25 device 22 is defined as a peripheral portion of the
object.

The focusing object controlling device 73 compares

the object real dimension calculated by the object dimension calculating device 72 with the object dimension set by the object dimension setting device 71. Then, if the two dimensions are substantially the same, the first and second focusing estimating parts 2 and 3 are controlled to focus on the object. That is, the first and second focusing estimating parts 2 and 3 are controlled to create the first and second estimated values with respect to the object. Whereas if the above two dimensions are not substantially the same, the first and second focusing estimating parts 2, 3 are controlled to focus on an object exclusive of the object concerned among the images on the imaging element 21. That is, the first and second focusing estimating parts 2, 3 are controlled to create the first and second focusing estimated values with respect to the object other than the object concerned. Note that this focusing object controlling device 73 is constructed of, e.g., a CPU (Central Processing Unit) or the like integrally with the focusing estimated value creating devices 23, 36 and the focusing method selecting device 4.

Next, an operation of the third embodiment will be described. The object dimension setting device 71 sets the dimension of the focusing object and transmits data about this dimension to the focusing object controlling device 73. On the other hand, the object dimension

calculating device 72 calculates the object real dimension to be considered as the first and second estimated values created by the first and second focusing estimating parts 2 and 3, and transmits data
5 about this dimension to the focusing object controlling device 73.

The focusing object controlling device 73 compares the object real dimension calculated by the object dimension calculating device 72 with the object
10 dimension set by the object dimension setting device 71. Then, if the two dimensions are substantially the same, the object concerned is judged to be the focusing object, and the first and second focusing estimating parts 2 and 3 are controlled to successively create the
15 first and second focusing estimated values with respect to the object concerned. Whereas if not substantially the same, the object concerned is judged not to be the focusing object, and the first and second focusing estimating parts 2 and 3 are controlled to create the
20 first and second focusing estimated values with respect to an object other than the object concerned. Then, the above comparison is repeated till the focusing object is detected from the images on the imaging element 21. Note that other operations in the third
25 embodiment are fundamentally the same as those in the first embodiment.

In accordance with the third embodiment of the

present invention, the focusing on the object is carried out only when the object real dimension calculated by the object dimension calculating device 72 is substantially coincident with the dimension set by the object dimension setting device 71. The autofocusing operation can be thereby performed with respect to only the object having the dimension substantially coincident with the dimension of the focusing object. It is therefore feasible to prevent the focusing on an unexpected object and an object traversing in front of the object concerned.

Moreover, the photographer is capable of varying the dimension of the focusing object corresponding to a condition when photographed by use of the object dimension setting device 71 by which the photographer can set the dimension of the focusing object.

Note that the focusing object is judged by making use of the crosswise dimension of the object in the third embodiment, but the present invention is not limited to this. According to the present invention, the focusing object can be judged by making use of dimensions in the perpendicular and oblique directions. In this case, the range of the object to be photographed can be further widened.

Also, in the third embodiment, the object dimension setting device 71 has been discussed so far as the one by which the photographer is capable of

inputting the dimension of the focusing object. The present invention is not, however, confined to this. For instance, it may be practiced that objects (human being, vehicle, etc.) generally exhibiting a high possibility of being focused may be expressed in graphics like symbols and characters, and the photographer arbitrarily selects any one of these graphics, thereby setting the dimension of the focusing object. For example, when the human being is selected, the dimension of the focusing object is set to 50 cm that can be considered as a standard body breadth of the human being. In this case, the graphics representing the human being, wire netting and vehicle are displayed on the finder of the video camera, and are selectable by a switch provided in another position different from the finder and a touch panel provided on the finder.

Further, in accordance with the third embodiment, the focusing object controlling device 73 has been explained so far as the one constructed to focus the object concerned only when the object real dimension calculated by the object dimension calculating device 72 is substantially the same as the dimension set by the object dimension setting device 71, the present invention is not, however, limited to this. For instance, if the object real dimension calculated by the object dimension calculating device 72 is

substantially the same as the dimension set by the
object dimension setting device 71, the focusing on the
object concerned may not be performed. With this
arrangement, the focusing on a specified object (e.g.,
5 wire netting or the like) is not allowed. Further, for
example, the photographer is able to make a selection
about whether the focusing is effected with the
dimension set by the object dimension setting device,
and, whether to focus on the object concerned may be
10 judged based on a selected content. In this case, the
object dimension setting device is preferably capable
of selecting the focusing object and non-focusing
objects (which must not be focused on) as illustrated
in Fig. 18. In the embodiment shown in Fig. 18, a
15 pointer 71e of a rotary type variable resistor 71d is
set to an arbitrary value of a focusing scale 71f or a
non-focusing scale 71g, thus setting this value to a
dimension of the focusing object or the non-focusing
object. Herein, each of the values of the scales 71f,
20 71g represents a crosswise size of the object. This
object dimension setting device outputs, to the
focusing object controlling device, resistance values
of the variable resistor 71, viz., signals
corresponding to a scale type (the focusing scale 71f
25 or the non-focusing scale 71g) pointed by the pointer
71e of the variable resistor 71d and to a value of the
scale.

Further, in accordance with the third embodiment, there has been described the way how the lens position is measured by the encoders 74, 75 for obtaining the positional data of the variable magnification lens 12
5 and of the focus adjusting lens 11. However, if open roof control is executed by use of a stepping motor as a driving source for each lens, it is possible to grasp the lens position at all times without any encoder.

Moreover, as explained in the first embodiment,
10 there are developed some of even the image deviation type autofocus apparatuses, which are capable of setting the focus area in a plurality of portions within the photographic area. If that kind of autofocus apparatus is used for the second focusing
15 estimating part 3 in the third embodiment, the crest climbing method and the image deviation method are used in combination for focusing the image corresponding to the object that exists in the portion concerned in the plurality of portions within the photographic area.
20 Also, the real dimension of the object can be thereby measured. This makes it feasible to focus on any one of the objects by letting the photographer select the focus area (e.g., the central portion of the photographic area) when, for example, as illustrated in
25 Fig. 19, objects Y_3 , Y_4 each having substantially the same dimension appear on the photographic area.

Note that the focusing method selecting device 4

and the focus estimated value creating device 23 of the first estimating part 2 are omitted, and the picture signal transmitted from the picture signal making device 22 of the first estimating part 2 may be used
5 exclusively for measuring the dimension of the object on the imaging element 21 in the third embodiment. In this case, the image on the imaging element 21 is focused on the corresponding object on the basis of the second focusing estimated value created by the second
10 focusing estimating part 3.

Next, a fourth embodiment of the present invention will be discussed with reference to the drawings.

Fig. 20 is a schematic block diagram illustrating the autofocus apparatus in a fourth embodiment of the
15 present invention. Fig. 21 is an explanatory diagram showing a focus area of the first focusing estimating part and a focus area of the second focusing estimating part. Fig. 22 is a diagram showing one example of a focus area inputting device used in the fourth
20 embodiment. Fig. 23 is an explanatory diagram showing an operation of a focus area setting device. Note that the elements having the same functions as those in the first embodiment shown in Fig. 10 are marked with the like or corresponding numerals in the fourth embodiment
25 of the present invention, and the detailed explanations thereof are omitted.

A different point of the autofocus apparatus in

the fourth embodiment illustrated in Fig. 20 from the first embodiment shown in Fig. 10, is that there are provided a focus area size inputting device 76, a focus area setting device 77 and a focus area display device 78. Other configurations are basically the same as those in the first embodiment.

The first focusing estimating part 2 using the crest climbing method creates the first focusing estimated value based on the picture signal obtained by the imaging element 21. Therefore, as illustrated in Fig. 21, the first focusing estimated value is created based on the picture signals by fetching the picture signals on the imaging element 21, these signals corresponding to arbitrary areas in the photographic area 21a photographed by the photographing optical system 1, e.g., areas 112a and 112b. That is, the first focusing estimating part 2 is capable of arbitrarily varying the focus area. On the other hand, the focus area of the second focusing estimating part 3 using the image deviation method is set in predetermined area depending on sizes of the image forming lens 32, the line sensors 34a, 34b and the image re-forming lenses 33a, 33b. Accordingly, the focus area of the second focusing estimating part 3 is not variable. In the autofocus apparatus in the fourth embodiment, the focus area of the second focusing estimating part 3 is, as illustrated in Fig. 21, set in

a vicinity-of-center 111 of the photographic area 21a. Further, the image processing device 35 executes predetermined image processing, thereby subdividing the focus area 111 into a plurality of unit areas 111a - 111i. Then, an image deviation is detected in each of the unit areas 111a - 111i.

The focus area size inputting device 76 is designed so that the photographer inputs data about the focus area of the first focusing estimating part 2. In an example shown in Fig. 22, a pointer 76b of a knob 76a consisting of a rotary type variable resistor is set to an arbitrary position of a scale 76c, thus designating a size of the focus area. For example, when the pointer 76b is set to "standard" of the scale 76c, the focus area of the first focusing estimating part 2 becomes substantially the same as the size of the focus area of the second focusing estimating part 3. Further, when the pointer 76b of the scale 76c is set on a "smaller area" side than the "standard area" position of the scale 76c, the focus area of the first focusing estimating part 2 becomes smaller than the focus area of the second focusing estimating part 3. Moreover, when the pointer 76b of the scale 76c is set on a "larger area" side than the "standard" position of the scale 76c, the focus area of the first focusing estimating part 2 is larger than the focus area of the second focusing estimating part 3. Note that a size

ratio of the focus area is set variable corresponding to a rotational quantity of the knob 76a on the basis of the "standard area" position of the scale 76c. Further, when the pointer 76b is set to "AUTO" 76d, the
5 focus area of the first focusing estimating part 2 is varied in accordance with a size of the object.

The focus area size inputting device 76 outputs, to a focus area setting device 77, a resistance value of the knob 76a, i.e., a signal corresponding to a
10 position pointed by the pointer 76b of the knob 76a. Note that a knob constructed of a slide type variable resistor and a multi-stage switch or an encoder may substitute for the knob 71a consisting of the rotary type variable resistor in Fig. 22. Further, an
15 operating portion may be displayed on the finder 79 of the video camera, and this operating portion may be selectable by a switch provided in a different position from the finder 79 or by a touch panel disposed on the finder 79. Moreover, the "AUTO" switch may be
20 separately provided, and the "AUTO" function may be switched ON and OFF by depressing the knob.

The focus area setting device 77 sets the focus area of the first focusing estimating part 2 on the basis of the signal transmitted from the focus area
25 size inputting device 76. For instance, when the "standard area" is inputted to the focus area size inputting device 76, as shown in Fig. 23, the focus

area of the first focusing estimating part 2 is set in substantially the same size and in the same position as those of the focus area 111 of the second focusing estimating part 3. Further, when the "larger area" is inputted to the focus area size inputting device 76, the focus area of the focusing estimating part 2 is set to an area 113b larger than the focus area 111 as well as in substantially the same position as the focus area 111 of the second focusing estimating part 3.

Furthermore, when the "smaller area" is inputted to the focus area size inputting device 76, the focus area of the focusing estimating part 2 is set to an area 113a smaller than the focus area 111 as well as in substantially the same position as the focus area 111 of the second focusing estimating part 3.

Further, when the "AUTO" is inputted to the focus area size inputting device 76, the focus area of the first focusing estimating part 2 is set in the following procedures. To start with, the focus area setting device 77, as shown in Fig. 24, obtains a distance from the photographing optical system 1 to the object for every object photographed in each of the unit areas 111a - 111i on the basis of an image deviation quantity detected in each of the unit areas 111a - 111i of the focus area 111 of the second focusing estimating part 3. Next, the focus area setting device 77 detects the unit areas adjacent to

each other and having substantially the same distance from the photographing optical system 1 to the object, from the unit areas 111a - 111i. It can be assumed that the identical object is photographed in the unit areas adjacent to each other and having substantially the same distance from the photographing optical system to the object. Hence, it can be judged that a size of the object corresponds to a region surrounded by these unit areas. Next, the focus area setting device 77 sets an area including the detected unit areas by way of the focus area of the first focusing estimating part 2. For example, referring to Fig. 24, when the unit areas 111c, 111d are detected, an area 114a is set as the focus area of the first focusing estimating part 2. Also, when the unit areas 111c - 111e are detected, an area 114b is set as the focus area of the first focusing estimating part 2.

Moreover, the focus area setting device 77 issues a command to the first focusing estimating part 2 to create the first focusing estimated value based on the thus set focus area. This focus area setting device 77 is so constructed of, e.g., the CPU (Central Processing Unit), etc. as to be integral with the focusing estimated value creating devices 23, 36 and the focusing method selecting device 4.

The focus area display device 78, when the focusing method selecting device 4 selects the first

focusing estimated value, displays the focus area of
the first focusing estimating part 2 on the finder 79
of the video camera, and, when selecting the second
focusing estimated value, displays the focus area of
5 the second focusing estimating part 3 thereon.
Incidentally, those areas may be displayed on a monitor
screen or the like as well as on the finder 79
together.

In the fourth embodiment of the present invention,
10 the size of the focus area of the first focusing
estimating part 2 may be made variable with respect to
the size of the focus area of the second focusing
estimating part 3. Therefore, the focus area making
use of advantages of the crest climbing method and of
15 the image deviation method, can be set.

For instance, when the focus area of the first
focusing estimating part 2 is set smaller than the
focus area of the second focusing estimating part 3, a
hitherto-undetectable minute object can be focused on
20 in the second focusing estimating part 3. Further, the
first estimating part 2 takes a charge of
correspondence to the minute object, and consequently
the accuracy can be decreased by increasing the
resolutions of the line sensors 34a, 34b of the second
25 focusing estimating part 3. A rise in the costs can be
thereby restrained.

Moreover, in accordance with the fourth embodiment

of the present invention, one of the focus areas of the first and second focusing estimating parts 2 and 3, which area is selected by the focusing method selecting device 4, is displayed on the finder 79, and hence the
5 photographer is able to always confirm the focus area.

Note that the focus area size inputting device 76 has been explained so far as the one capable of inputting both of the manual adjustment and the auto control in the fourth embodiment of the present
10 invention, but the present invention is not confined to this. For instance, as illustrated in Fig. 25, only two kinds of items "standard area" and "AUTO" with an omission of the manual adjustment may be switched over by a switch, or reversely, with an omission of "AUTO",
15 the setting is done by only the manual knob. Also, as shown in Fig. 26, four sorts of items "standard area", "large area", "small area" and "AUTO" may be switched over by the switch.

Further, as discussed in the first embodiment,
20 some of even the image deviation type autofocus apparatuses have been developed so as to be capable of setting the plurality of portions within the photographic area as the focus area. If the autofocus apparatus of this kind is used for the second focusing
25 estimating part 3 in the fourth embodiment, as illustrated in Fig. 27, even the image deviation type apparatus is capable of setting the focus area over the

plurality of areas 115. Therefore, the focus area size inputting device 76 is set to "AUTO", whereby the distance from the photographing optical system 1 to the object can be obtained for every object photographed within the focus areas 115 on the basis of the image deviation quantity in each of the focus areas 115. A size of the object can be thereby determined, and hence the focus area of the first focusing estimating part 2 can be set corresponding to the size of the object.

Note that when the autofocus apparatus in each of the first through fourth embodiments is applied to the video camera, etc., it is a general construction that a lens barrel incorporates the photographing optical system 1 and the motor 5, and a camera body incorporates other constructive elements. The present invention is not, however, limited to this construction.

Next, a fifth embodiment of the present invention will be discussed with reference to the drawings.

Fig. 28 is a schematic block diagram illustrating the autofocus apparatus in the fifth embodiment of the present invention. Note that the elements having the same functions as those in the first embodiment shown in Fig. 10 or the third embodiment shown in Fig. 15 are marked with the like or corresponding numerals in the fifth embodiment of the present invention, and the detailed explanations thereof are omitted.

The autofocus apparatus in the fifth embodiment,

as illustrated in Fig. 28, includes a photographing optical system 1a, the first focusing estimating part 2, the motor 5, the motor driving device 6, the object dimension setting device 71, the object dimension calculating device 72, the focusing object controlling device 73, the focus adjusting lens encoder 74, the variable magnification lens encoder 75, and a distance measuring device 86. Herein the first focusing estimating part 2, the motor 5 and the motor driving device 6 are identical with those used in the first embodiment. Further, the object dimension setting device 71, the object dimension calculating device 72, the focusing object controlling device 73, the focus adjusting lens encoder 74, and the variable magnification lens encoder 75 are identical with those employed in the third embodiment.

A different point of the photographing optical system 1a from the photographing optical system 1 used in the first embodiment is that the optical element 15 for splitting the light beam is removed therefrom. Others are the same as those in the photographing optical system 1. The distance measuring device 86 measures a distance from the photographing optical system 1a to the object that corresponds to the first focusing estimated value created by the first focusing estimating part 2. A distance measuring method that can be considered may be a method involving the use of

infrared rays.

In accordance with the fifth embodiment of the present invention, a real dimension of the object can be measured by providing the distance measuring device 5 86 for measuring the distance from the photographing optical system 1a in the autofocus apparatus constructed to perform the focusing by use of only the crest climbing method. Further, in the distance measuring device 86, the accuracy for calculating the 10 dimension of the object may suffice, and there is no necessity for making a high-accuracy measurement. It is therefore feasible to perform the autofocus operation for only the object having substantially the same dimension as the dimension set by the object 15 dimension setting device 71, or executing the autofocus operation for only the object having a dimension exclusive of the dimension set by the object dimension setting device 71. Accordingly, it is possible to prevent the focusing on an unexpected object and an 20 object traversing in front of the object concerned.

The present invention is not confined to the respective embodiments discussed above but may be modified in many ways within the gist thereof. Further, the autofocus apparatus in each of the 25 embodiment stated above can be used for not only the video camera but also other cameras such as an electronic still camera, etc..

A sixth embodiment of the present invention will hereinafter be described with reference to the drawings.

Fig. 29 is a schematic block diagram showing a TV camera in the sixth embodiment of the present invention. Fig. 30 is an explanatory flowchart showing an autofocus operation of the TV camera illustrated in Fig. 29.

The TV camera in the sixth embodiment comprises, as shown in Fig. 29, a camera body 9 and a lens barrel 8 attached to the camera body 9. The lens barrel 8 is so constructed as to be attachable to the camera body 9, and the user is able to replace the lens barrel 8 to be attached to the camera body according to the application.

The camera body 9 includes a first focusing estimating part 20, an AF processing circuit 40, and a connector 61. Further, the lens barrel 8 includes a photographing optical system 10, a second focusing estimating part 30, a motor 50, a motor driving circuit 60, and a connector 62. Note that the connectors 61, 62 are, when the lens barrel 8 is attached to the camera body 9, so constructed as to be electrically connected to each other.

The photographing optical system 10 of the lens barrel 8 is constructed of four lens units such as a focus adjusting lens 11, a variable magnification lens

12, a correcting lens 13 and an image forming lens 14.
This construction is typical of the lens barrel for the
TV camera. In the photographing optical system 10 used
in the sixth embodiment, a beam splitting element
5 (e.g., a beam splitter) 45 for splitting light beams
and a stop 16 are interposed in between the correcting
lens 13 and the image forming lens 14. Note that the
optical element 45 is disposed anterior to the stop 16
so that the light beams can be transmitted to the
10 second focusing estimating part 30 irrespective of an
aperture quantity of an aperture stop of the
photographing optical system 10 in the sixth
embodiment.

The first focusing estimating part 20 estimates
15 focusing by a so-called crest climbing type autofocus
system. The first focusing estimating part 20
includes, the imaging element 21 for picking up an
image formed by the image forming lens 14 of the
photographing optical system 10 and converting it into
20 an electric signal, and the picture signal making
device 22 for generating a picture signal corresponding
to the electric signal transmitted from the imaging
element 21. The first focusing estimating part 20 also
includes the focusing estimated value creating device
25 23 for creating an item of focusing data (termed also a
first focusing estimated value) for focusing the image
on the imaging element 21 on the basis of the picture

signal given from the picture signal making device 22. The focusing estimated value creating device 23 has a level detecting portion 23a for detecting a level of a proper frequency component from the picture signal
5 generated by the picture signal making device 22, and an estimated value creating portion 23b for creating the first focusing estimated value by examining the level detected by the level detecting portion 23a.

Next, the first focusing estimated value created
10 by the focusing estimated value creating device 23 will be explained. As described in the prior art, the picture signal is, it can be assumed, formed by synthesizing sine waves of a plurality of frequencies. Then, it is empirically known that a level of high
15 frequency component of the picture signal, as illustrated in Fig. 2, rises more steeply according as a degree of sharpness of the image formed on the imaging element 21 increases, i.e., the focus adjusting lens 11 moves closer to a focusing point A, and this
20 level reaches a peak when the image on the imaging element 21 is focused on. Subsequently, the focusing estimated value creating device 23 selects a proper high frequency component in consideration of an S/N ratio of the picture signal as well as of an imaging
25 performance of the photographing optical system 10, out of the picture signal obtained by the picture signal making device 22. Then, the focusing estimated value

creating device 23 creates a focusing estimated value by monitoring a level of this frequency component at a predetermined sampling interval. For example, when the level of the selected frequency component rises, it is
5 estimated that the focus adjusting lens 11 is moving in such a direction as to approach a focusing point. Further, when the level of the selected frequency component lowers, it is estimated that the focus adjusting lens 11 is moving in such a direction as to
10 get away from the focusing point. Then, when the level of the selected frequency component exists within a predetermined range (shown by, e.g., ΔV in Fig. 2) from the peak value, it is estimated that the image on the imaging element 21 is focused on.

15 The second focusing estimating part 30 estimates focusing by using an autofocus system known as the image deviation method. The second focusing estimating part 30 comprises the mirror 31 for reflecting the light beam split by the beam splitting element 45,
20 toward a predetermined direction, and the image forming lens 32 for forming light beams incident via the mirror 31 into a conjugate image. The second focusing estimating part 30 further comprises the image re-forming lenses 33a, 33b for forming some of the light
25 beams image formed by the image forming lens 32, again into images, the line sensors 34a, 34b for respectively picking up the images formed by the image re-forming

lenses 33a, 33b and converting them into electric signals, the image processing device 35, and the focusing estimated value creating device 36.

5 The image forming lens 32 is disposed so that the light beams incident via the mirror 31 are image-formed on the predetermined focal surface 37 when the image on the imaging element 21 is focused on. The image re-
forming lenses 33a, 33b are disposed in positions substantially symmetric with respect to the optical
10 axis of the image forming lens 32. The line sensors 34a, 34b are disposed in the positions substantially symmetric with respect to the optical axis of the image forming lens 32 and on a predetermined focal surface of the image re-forming lenses 33a, 33b corresponding to
15 each other. The image processing device 35 executes the image processing based on the electric signals transmitted respectively from the line sensors 34a, 34b. The focusing estimated value creating device 36 creates an item of data (also called a second focusing
20 estimated value) for focusing the image formed on the imaging element 21 on the basis of the signal transmitted from the image processing device 35. The focusing estimated value creating device 36 includes a positional deviation detecting portion 36a for
25 detecting an imaging positional deviation (a deviating direction and a deviation quantity) between the image on the imaging element 34a and the image on the imaging

element 34b on the basis of the signal transmitted from
the image processing device 35, and an estimated value
creating portion 36b for creating a second focusing
estimated value based on the imaging positional
5 deviation detected by the positional deviation
detecting portion 36a.

Herein, the second focusing estimated value
created by the focusing estimated value creating device
36 will be explained. Figs. 31, 33 and 35 are
10 partially enlarged diagrams of the second focusing
estimating part 30, showing the principle of the image
deviation type autofocus system. Herein, Fig. 31
illustrates a light path when in a focused state.
Figs. 33 and 35 illustrate optical paths when in a
15 defocused state.

As illustrated in Fig. 31, the light beams passing
through the image forming lens 32 are focused upon the
predetermined focal surface 37, some of the light beams
are again image formed on the line sensors 34a, 34b by
20 the image re-forming lenses 33a, 33b. Herein, when
focused on the predetermined focal surface 37, the
images picked up by the two line sensors 34a, 34b are
formed in substantially coincident positions on the
line sensors as shown in Fig. 32. On the other hand,
25 as shown in Fig. 33, when the light beams passing
through the image forming lens 32 are focused on
anterior to the predetermined focal surface 37 (which

is a so-called rear focus state), there must be a deviation between images D_1 , D_2 picked up by the two line sensors 34a, 34b. Also, as illustrated in Fig. 35, when the light beams passing through the image forming lens 32 are focused on posterior to the predetermined focal surface 37 (which is a so-called a front focus state), there must be a deviation between in a direction opposite to the one in the rear focus state between the images D_1 , D_2 picked up by the two line sensors 34a, 34b. Then, the focusing estimated value creating device 36 detects a deviation quantity and a deviating direction between the images D_1 , D_2 picked up by the line sensors 34a, 34b, and, based on the data thereof, creates a moving direction and a moving quantity (a second focusing estimated value) of the focus adjusting lens 11, which are needed for focusing the image on the predetermined focal surface 37, i.e., the image on the imaging element 21. Note that the second focusing estimated value is created at the interval of a predetermined time in consideration of a processing speed, etc. of the image processing device 35.

Thus, in the image deviation type autofocus system, the focusing is effected based on the deviating direction and the deviation quantity between the positions of the images picked up by the pair of line sensors. This is the reason why it is called the image

deviation method. According to the image deviation
type autofocus system, the required-for-focusing moving
direction and moving quantity of the focus adjusting
lens are directed calculated based on the deviating
5 direction and the deviation quantity between the
positions of the images picked up by the pair of line
sensors, and therefore the focusing can be quickly
carried out. For this reason, the apparatus is
employed as an autofocus apparatus mainly for a still
10 camera.

The AF processing circuit 40 of the camera body 9
has motor driving signal generating portions 41, 42,
and a selecting portion 43. The motor driving signal
generating portion 41 refers to the first focusing
15 estimated value created by the first focusing
estimating part 20, and thus generates a drive signal
of the motor 50. For instance, if the first focusing
estimated value represents such an estimation that the
focus adjusting lens 11 is moving in such a direction
20 as to approach the focusing point, the drive signal is
generated to make a rotating direction of the motor 50
remain unchanged. Further, if the first focusing
estimated value represents such an estimation that the
focus adjusting lens 11 is moving in such a direction
25 as get away from the focusing point, the drive signal
is generated to reverse the rotating direction of the
motor 50. The motor driving signal generating portion

42 refers to the second focusing estimated value created by the second focusing estimating part 30 and transmitted via the connectors 61, 62, and thus generates the drive signal to move the focus adjusting lens 11 in the moving direction with the moving quantity, which are indicated by the estimated value concerned. The selecting portion 43 selects at least one of the drive signal generated by the motor driving signal generating portion 41 and the drive signal generated by the motor driving signal generating portion 42. In the sixth embodiment, referring to the second focusing estimated value, if the required-for-focusing moving quantity of the focus adjusting lens 11 is larger than a threshold value, the drive signal generated by the motor driving signal generating portion 42, is selected. Whereas if smaller than the threshold value, the drive signal generated by the motor driving signal generating portion 41, is selected. Note that this threshold value may be arbitrarily set by the photographer or the like with inputting from outside or by some other methods. The thus selected drive signals are transmitted via the connectors 61, 62 to the motor driving circuit 60.

The motor driving circuit 60 of the lens barrel 8 drives the motor 50 based on the drive signal selected by the selecting portion 43. The focus adjusting lens 11 is thereby moved forward and backward in the

optical-axis direction of the photographing optical system 10.

Note that the picture signal making device 22, the focusing estimated value creating device 23 and the AF processing circuit 40 of the camera body 9 are integrally constructed of, e.g., the CPU (Central Processing Unit), etc.. Similarly, the image processing device 35 and the focusing estimated value creating device 36 of the lens barrel 8 are also integrally constructed of the CPU (Central Processing Unit), etc..

Next, the autofocus operation of the TV camera in the sixth embodiment will be explained with reference to Fig. 30.

At the first onset, upon an incidence of the light beams emerging from the object on the photographing optical system 10, the first focusing estimating part 20 creates the first focusing estimated value based on the light beams obtained through the image forming lens 14 in the photographing optical system 10. Further, the second focusing estimating part 30 creates the second focusing estimated value based on the light beam split by the beam splitting element 45 in the photographing optical system 10 (step 201).

Next, the selecting portion 43 of the AF processing circuit 40 judges whether or not the first focusing estimated value gives an indication of being

focused (step 202). If the first focusing estimated value indicates a purport of being focused, a flow of processing shown in Fig. 30 comes to an end. Whereas if not, the processing proceeds to step 203.

5 In step 203, the selecting portion 43 of the AF processing circuit 40 refers to the second focusing estimated value, and judges whether or not the required-for-focusing moving quantity of the focus adjusting lens 11 is under the threshold value. If the
10 required-for-focusing moving quantity of the focus adjusting lens 11 is under the threshold value, the drive signal generated by the motor drive signal generating portion 41 is selected based on the first focusing estimated value (step 204). While on the
15 other hand, if over the threshold value, the drive signal generated by the motor driving signal generating portion 42 is selected based on the second focusing estimated value (step 205).

 Next, the motor driving device 60 drives the motor
20 on the basis of the drive signal selected by the selecting portion 43 (step 206).

 The processing flow shown in Fig. 30 is repeatedly executed till the first focusing estimated value comes to have a content of being focused. The image on the
25 imaging element 21 is thereby focused on.

 In the sixth embodiment, the first focusing estimated value is created by the first focusing

estimating part 20 involving the use of the crest
climbing type autofocus system capable of focalizing
with a high precision. Then, the second focusing
estimated value is created by the second focusing
5 estimating part 30 involving the use of the image
deviation type autofocus system capable of quick
focalizing. Further, the AF processing circuit 40, if
the second focusing estimated value created by the
second focusing estimating part 30 is over the
10 threshold value, selects the second focusing estimated
value, and, whereas if under the threshold value,
selects the first focusing estimated value. Then, the
drive signal for the motor 50 is generated based on the
thus selected focusing estimated value. With this
15 processing, to begin with, the image on the imaging
element 21 is roughly focused on by making use of the
second focusing estimated value. Thereafter, the image
on the imaging element 21 is finely focused on by use
of the first focusing estimated value. Accordingly, in
20 the sixth embodiment, it is feasible to focus the image
on the imaging element 21 quickly with the high
accuracy. Further, the high precision is not demanded
of the second focusing estimating part 30 employing the
image deviation method, and consequently an increase in
25 costs can be restrained.

Moreover, in the sixth embodiment, the first
focusing estimating part 20 is provided on the side of

the camera body 1, while the second focusing estimating part 20 is provided on the side of the lens barrel. Herein, the first focusing estimating part 20 creates the focusing estimated value for focusing the image on the imaging element 21 on the basis of the image on the imaging element 21, and can be therefore used in common irrespective of the structure of the photographing optical system 10. On the other hand, the second focusing estimating part 30 creates the focusing estimated value for focusing the image on the imaging element 21 by use of the image to be formed in a different position from the surface on the imaging element 21, and might therefore need to change the structure (especially, a layout of the image forming lens 32 and the image re-forming lenses 33a, 33b) if the structure of the photographing optical system 10 varies. As discussed above, in accordance with the sixth embodiment, the camera body 1 is provided with the first focusing estimating part 20 capable of being used in common, regardless of the structure of the photographing optical system 10, i.e., even when replacing the lens barrel. Then, the lens barrel 2 is provided with the second focusing estimating part 30 peculiar to the photographing optical system 10, thereby making it possible to prevent the rise in costs for the lens barrel as well as to downsize the lens barrel.

Moreover, in the sixth embodiment, the focal length of the optical system for forming the images for detecting the image deviation on the line sensors 34a, 34b, is a synthetic focal length of the focus adjusting lens 11, the variable magnification lens 12, the correcting lens 13 and the image forming lens 32. On the other hand, the focal length of the optical system for forming the image for the picture signal on the imaging element 21, is a synthetic focal length of the focus adjusting lens 11, the variable magnification lens 12, the correcting lens 13 and the image forming lens 14. Accordingly, the focal lengths of the optical system for forming the images for detecting the image deviation and of the optical system for forming the image for the picture signal, are varied by changing the configurations of the image forming lenses 14, 32. Videlicet, the sizes of the images formed by the respective optical systems can be varied. For example, the image forming lens 32 is constructed to enlarge the image for detecting the image deviation by elongating the focal length of the optical system for forming the images for detecting the image deviation, thereby obtaining a finer pixel pitch of the line sensors 34a, 34b relative to the above image. Hence, it is feasible to focus on even a minute object. Further, for instance, the image forming lens 32 is constructed to diminish the image for detecting the image deviation by

shortening the focal length of the optical system for forming the image for detecting the image deviation, whereby a size of this image decreases relatively to the line sensors 34a, 34b. Therefore, a detectable
5 image deviation quantity increases. Such being the case, even when the focus adjusting lens is positioned far from the focusing point (a so-called largely defocused state), the focusing point can be quickly detected. Further, the lens barrel can be downsized.

10 Note that the selecting portion 43 of the AF processing circuit 40 is permitted to judge whether or not the lens barrel 8 should include the second focusing estimating part. This judgement may be made based on whether or not the signal indicating the
15 second focusing estimated value is transmitted from the lens barrel via the connectors 61, 62. Also, the connector 62 of the lens barrel 8 may be provided with a contact point for distinguishing an existence or non-existence of the second focusing estimating part, and
20 the selecting portion 43 may make a judgement about this contact point. If the lens barrel 2 does not include the second focusing estimating part, the drive signal generated by the driving signal generating portion 41 is selected based on the first focusing
25 estimated value, whereby the lens barrel corresponding to the hitherto-used crest climbing type autofocus system can be also employed. Moreover, if the lens

barrel 8 has the second focusing estimating part, the focusing data created by the second focusing estimating part incorporated into the lens barrel 8 can be effectively availed.

5 Next, a seventh embodiment of the present invention will be explained with reference to the drawings.

10 Fig. 37 is a schematic block diagram of the TV camera in the seventh embodiment of the present invention. Note that the elements having the same functions as those in the sixth embodiment shown in Fig. 29 are marked with the like or corresponding numerals in the seventh embodiment of the present invention, and the detailed explanations thereof are
15 omitted.

20 A different point of the TV camera in the seventh embodiment from that in the sixth embodiment shown in Fig. 29 is that the camera body 1a is, as illustrated in Fig. 37, provided with an AF processing circuit 40a instead of the AF processing circuit 40, and that the
25 lens barrel 8 is provided with an AF processing circuit 40b. The AF processing circuit 40a includes the motor driving signal generating portion 41. The AF processing circuit 40b includes the motor driving signal generating portion 42 and the selecting portion 43.

 In the seventh embodiment, the lens barrel 8

incorporates the AF processing circuit 40b consisting
of the motor driving signal generating portion 42 for
generating the motor driving signal on the basis of the
second focusing estimated value, and the selecting
5 portion 43 for selecting at least one of the drive
signal generated by the motor driving signal generating
portion 41 and the drive signal generated by the motor
driving signal generating portion 42. With this
construction, there can be used the camera body 9a
10 corresponding to the hitherto-employed crest climbing
type autofocus system as illustrated in Fig. 9. That
is, in accordance with the seventh embodiment, even
when using the camera body corresponding to the
hitherto-used crest climbing type autofocus system, the
15 image on the imaging element 21 can be focused on
quickly with the high precision. Other effects are the
same as those in the first embodiment.

Note that the selecting portion 43 of the AF
processing circuit 40b is permitted to judge whether or
20 not the camera body 9a includes the first focusing
estimating part. This judgement may be made based on
whether or not the motor driving signal is transmitted
from the camera body 9a via the connectors 61, 62.
Further, the connector 61 of the camera body may be
25 provided with a contact point for distinguishing an
existence or non-existence of the first focusing
estimating part, and the selecting portion 43 may make

a judgement about this contact point. If the camera body 9a does not have the first focusing estimating part, the drive signal generated by the driving signal generating portion 42 is selected based on the second focusing estimated value, whereby the autofocus function can be actualized even when the camera body not corresponding to the autofocus is attached to the lens barrel 8a. Moreover, in the case of the lens barrel 8a being fitted with the camera body corresponding to the autofocus, the autofocus function of the camera body can be effectively availed.

Next, an eighth embodiment of the present invention will be described with reference to the drawings.

Fig. 38 is a schematic block diagram of the TV camera in the eighth embodiment of the present invention. Note that the elements having the same functions as those in the sixth embodiment shown in Fig. 29 are marked with the like or corresponding numerals in the eighth embodiment, and the detailed explanations thereof are omitted.

A different point of the TV camera in the eighth embodiment from that in the sixth embodiment shown in Fig. 29 is that the lens barrel 8b is, as illustrated in Fig. 38, provided with the AF processing circuit 40 and the focusing estimated value creating device 23 of the first focusing estimating part.

In the eighth embodiment, the lens barrel 8b incorporates the focusing estimated value creating device 23, the second focusing estimating part 30 and the Af processing circuit 40. With this construction, even when the camera body not corresponding to the autofocus is attached to the lens barrel 8b, the image on the imaging element 21 can be focused on quickly with the high accuracy by using the two sorts of image deviation type and crest climbing type autofocus systems.

Note that the picture signal making device 22 may be disposed on the side of the lens barrel 8b in the eighth embodiment.

Next, a ninth embodiment of the present invention will be described with reference to the drawings.

Fig. 39 is a schematic block diagram of the TV camera in the ninth embodiment of the present invention. Note that the elements having the same functions as those in the sixth embodiment shown in Fig. 29 are marked with the like or corresponding numerals in the ninth embodiment, and the detailed explanations thereof are omitted.

The TV camera in the ninth embodiment includes, as illustrated in Fig. 39, a camera body 9c and a lens barrel 8c attached to the camera body 9c. The camera body 9c has the imaging element 21, the picture signal making device 22 and the connector 61. Further, the

lens barrel 8c has the photographing optical system 10,
the focusing estimated value creating device 23, the
processing circuit 40c, the motor 50, the motor driving
circuit 60 and the connector 62. The AF processing
5 circuit 40c has the drive signal generating portion 41
for generating the drive signal for the motor 50 by
referring to the focusing estimated value created by
the focusing estimated value creating device 23.

In accordance with the ninth embodiment, the lens
10 barrel 8c incorporates the crest climbing type
autofocus function to create the focusing estimated
value on the basis of the image on the imaging element
21 in the camera body 9c. With this construction, even
when the camera body not corresponding to the autofocus
15 is attached to the lens barrel, the image on the
imaging element 21 can be focused on with the high
precision by employing the crest climbing type
autofocus system.

Next, a tenth embodiment of the present invention
20 will be discussed with reference to the drawings.

Fig. 40 is a schematic diagram of the TV camera in
the tenth embodiment of the present invention. Note
that the elements having the same functions as those in
the sixth embodiment shown in Fig. 29 are marked with
25 the like or corresponding numerals in the tenth
embodiment, and the detailed explanations thereof are
omitted.

The TV camera in the tenth embodiment includes, as illustrated in Fig. 40, a camera body 9d and a lens barrel 8d attached to the camera body 9d. The camera body 9d has the imaging element 21. Further, the lens barrel 8d has the photographing optical system 10, the second focusing estimating part 30, an Af processing circuit 40d, the motor 50, and the motor driving circuit 60. The AF processing circuit 40d has the drive signal generating portion 42 for generating the drive signal for the motor 50 by referring to the focusing estimated value created by the second focusing estimating part 30.

In accordance with the tenth embodiment, the lens barrel 8d incorporates the image deviation type autofocus function to directly calculate the required-for-focusing moving direction and moving quantity of the focus adjusting lens 11. With this construction, even when the camera body not corresponding to the autofocus is attached to the lens barrel, the image on the imaging element 21 can be focused on quickly by employing the image deviation type autofocus system.

The present invention is not limited to the respective embodiment discussed above but may be modified in a variety of forms within the scope of the gist thereof. for instance, the focusing estimated value creating device 23 for creating the focusing estimated value (the first focusing estimated value)

5 22. The first focusing estimated value may be,
however, created based on the electric signal outputted
from the imaging element 21. Also, a predetermined
process for creating the first focusing estimated value
is executed upon the electric signal outputted from the
10 imaging element 21, and the first focusing estimated
value may be created based on the signal undergoing
this process.

Further, the AF processing circuit 43 has been described so far by way of the one for selecting at least one of the drive signal generated by the motor driving signal generating portion 41 and the drive signal generated by the motor drive signal generating portion 42. The present invention is not, however, confined to this. The selecting portion may be constructed to select at least one of the first and second focusing estimated values. In this case, the motor driving signal generated based on the thus selected focusing estimated value may be transmitted to the motor driving circuit 60.

25 Further, the present invention may be applied to
not only the TV camera but also other video cameras and
electronic still cameras, etc..

An eleventh embodiment of the present invention will hereinafter be described with reference to the drawings.

Fig. 41 is a schematic block diagram showing the autofocus apparatus in the eleventh embodiment of the present invention. Fig. 42 is an explanatory flowchart showing an operation of the autofocus apparatus illustrated in Fig. 41. Fig. 43 is an explanatory flowchart showing an operation of the first focusing estimating part shown in Fig. 41. Fig. 44 is an explanatory flowchart showing an operation of the second focusing estimating part depicted in Fig. 41. Fig. 45 is an explanatory flowchart showing an operation of a defocus storage device shown in Fig. 41.

The autofocus apparatus in the eleventh embodiment includes, as illustrated in Fig. 41, the photographing optical system 1, the first focusing estimating part 2, the second focusing estimating part 3, the focusing method selecting device 4, the motor 5, the motor driving device 6, and a defocus storage device 7. Note that when the autofocus apparatus in the eleventh embodiment is applied to the video camera, etc., it is a general construction that the lens barrel incorporates the photographing optical system 1 and the motor 5, while the camera body incorporates other constructive elements. The present invention is not, however, limited to this construction.

The photographing optical system 1 is constructed of four lens units such as the focus adjusting lens 11, the variable magnification lens 12, the correcting lens 13 and the image forming lens 14. This construction is typical of the lens barrel for the TV camera. In the photographing optical system 1 used in the eleventh embodiment, the optical element (e.g., the beam splitter) 45 for splitting light beams and the stop 16 are interposed in between the correcting lens 13 and the image forming lens 14. Note that the optical element 45 is disposed anterior to the stop 16 so that the light beams can be transmitted to the second focusing estimating part 3 irrespective of an aperture quantity of an aperture stop of the photographing optical system 1 in the eleventh embodiment.

The first focusing estimating part 2 estimates the focusing by the so-called crest climbing method. The first focusing estimating part 2 includes the imaging element 21 for picking up an image formed by the image forming lens 14 of the photographing optical system 1 and converting it into an electric signal, and a picture signal making device 22 for generating a picture signal corresponding to the electric signal transmitted from the imaging element 21. The first focusing estimating part 2 also includes the focusing estimated value creating device 23 for creating the data (the first focusing estimated value) for focusing

the image on the imaging element 21 on the basis of the picture signal given from the picture signal making device 22. The focusing estimated value creating device 23 has the level detecting portion 23a for
5 detecting a level of a proper frequency component from the picture signal generated by the picture signal making device 22, and the estimated value creating portion 23b for creating the first focusing estimated value by examining the level detected by the level
10 detecting portion 23a. Note that the electric signal outputted from the imaging element 21 is used for generating the picture signal of the video camera as illustrated in Fig. 41.

The second focusing estimating part 3 estimates
15 the focusing by the so-called image deviation method. The second focusing estimating part 3 comprises the mirror 31 for reflecting the light beam split by the optical element 45, toward a predetermined direction, and the image forming lens 32 for forming the light
20 beams incident via the mirror 31 into a conjugate image. The second focusing estimating part 3 further comprises the image re-forming lenses 33a, 33b for forming some of the light beams image formed by the image forming lens 32, again into images, the line
25 sensors 34a, 34b for respectively picking up the images formed by the image re-forming lenses 33a, 33b and converting them into electric signals, the image

processing device 35, and the focusing estimated value creating device 36.

The image re-forming lenses 33a, 33b are disposed in positions substantially symmetric with respect to the optical axis of the image forming lens 32. More specifically, the image reforming lenses 33a, 33b are so disposed as to individually re-form the images of the light beams passing through portions having different pupils in the optical system consisting of the focus adjusting lens 11, the variable magnification lens 12, the correcting lens 13 and the image forming lens 32, among the light beams for forming the image formed by the image forming lens 32. The line sensors 34a, 34b are disposed in the positions substantially symmetric with respect to the optical axis of the image forming lens 32 and on a predetermined focal surface of the image re-forming lenses 33a, 33b corresponding to each other. The image processing device 35 executes the image processing based on the electric signals transmitted respectively from the line sensors 34a, 34b. The focusing estimated value creating device 36 creates the data (hereinafter termed also the second focusing estimated value) for focusing the image on the imaging element 21 on the basis of the signal transmitted from the image processing device 35. The focusing estimated value creating device 36 includes the positional deviation detecting portion 36a for

detecting an imaging positional deviation (a deviating direction and a deviation quantity) between the image on the imaging element 34a and the image on the imaging element 34b on the basis of the signal transmitted from the image processing device 35. The focusing estimated value creating device 36 also comprises a correcting portion 36b for correcting the imaging positional deviation detected by the positional deviation detecting portion 36a, with a correction value stored in a defocus quantity storage device 7 which will be mentioned alter on, and an estimated value creating portion 36c for creating the second focusing estimated value based on the imaging positional deviation corrected by the correcting portion 36b.

The defocus quantity storage device 7 stores, as a correction value, a defocus quantity between the image on the predetermined focal surface 37 and the image on the imaging element 21. Incidentally, if a non-volatile memory is used as a storage medium of the defocus storage device 7, the defocus quantity can be retained even in such a case that the power supply of the apparatus in the eleventh embodiment is, after being switched OFF, again switched ON. Hence, the image positional deviation detected by the positional deviation detecting portion 36a can be immediately corrected with the relevant defocus quantity.

The focusing method selecting device 4 selects at

least one of the first focusing estimated value created by the first focusing estimating part 2 and the second focusing estimated value created by the second focusing estimating part 3. In accordance with the eleventh
5 embodiment, referring first to the second focusing estimated value, if the defocus quantity or the required-for-focusing moving quantity of the focus adjusting lens 11 is larger than a threshold value, the second focusing estimated value is set to be selected.
10 Whereas if smaller than the threshold value, the first focusing estimated value is set to be selected. Note that this threshold value may also be set arbitrarily by the photographer and so forth through inputting from outside.

15 The motor driving device 6 drives the motor 5 on the basis of the focusing estimated value selected by the focusing method selecting device 4. Based on a command given from the motor driving device 6, the motor 5 moves the focus adjusting lens 11 forward and
20 backward in the optical-axis direction of the photographing optical system 1.

Incidentally, the focusing estimated value creating devices 23, 36, the focusing method selecting device 4 and the defocus quantity storage device 7 are
25 integrally constructed of, e.g., the CPU (Central Processing Unit), etc..

Next, an operation of the autofocus apparatus as a

whole in the eleventh embodiment will be described referring to Fig. 42.

To start with, upon an incidence of the light beams upon the photographing optical system 1 from the object, the first focusing estimating part 2 creates the first focusing estimated value on the basis of the light beams obtained via the image forming lens 14 in the photographing optical system 1. Further, the second focusing estimating part 3 creates the second focusing estimated value based on the light beams split by the optical element 45 in the photographing optical system 1 (step 251).

Next, the focusing method selecting device 4 judges whether or not the first focusing estimated value gives an indication of being focused (step 252). If the first focusing estimated value indicates a purport of being focused, a flow of processing shown in Fig. 42 comes to an end. Whereas if not, the processing proceeds to step 253.

In step 253, the focusing method selecting device 4 refers to the second focusing estimated value, and judges whether or not the defocus quantity or the required-for-focusing moving quantity of the focus adjusting lens 11 is under the threshold value. If the required-for-focusing moving quantity of the focus adjusting lens 11 is under the threshold value, the first focusing estimated value created by the first

focusing estimating part 2 is selected (step 254).

Whereas if above the threshold value, the second focusing estimated value selected by the second focusing estimating part 3 is selected (step 255).

5 Next, the motor driving device 6 drives the motor on the basis of the focusing estimated value selected by the focusing method selecting device 4 (step 256). When the second focusing estimated value is selected by the focusing method selecting device 4, the motor
10 driving device 6 drives the motor 5 so that the focus adjusting lens 11 is moved in the moving direction by the moving quantity, which are indicated by the selected second focusing estimated value. Further, when the first focusing estimated value is selected by
15 the focusing method selecting device 4, it is estimated that the focus adjusting lens 11 is moving in such a direction as to approach a focusing point. At this time, the motor 5 is driven to make the rotating direction thereof remain unchanged. Moreover, when it
20 is estimated that the focus adjusting lens 11 is moving in such a direction as to get away from the focusing point, the motor 5 is driven to reverse the rotating direction thereof.

 The processing flow shown in Fig. 42 is repeatedly
25 executed till the first focusing estimated value comes to have a content of being focused. The image on the imaging element 21 is thereby focused on.

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Subsequently, an operation of the first focusing estimating part 2 in the eleventh embodiment will be explained with reference to Fig. 43.

At first, the picture signal making device 22
5 converts the image formed on the imaging element 21 through the photographing optical system 1 into a picture signal (step 301). As described in the prior art, the picture signal is, it can be assumed, formed by synthesizing sine waves of a plurality of
10 frequencies. Then, it is well known that a level of high frequency component of the picture signal, as illustrated in Fig. 47, rises more steeply according to a degree of sharpness of the image formed on the imaging element 21 increases, i.e., the focus adjusting
15 lens 11 moves closer to a focusing point A, and this level reaches a peak when the image on the imaging element 21 is focused on. Subsequently, the focusing estimated value creating device 23 causes a level detecting portion 23a to detect a proper high frequency
20 component level at a predetermined sampling interval in consideration of an S/N ratio of the picture signal as well as of an imaging performance of the photographing optical system 1, out of the picture signal obtained by the picture signal making device 22 (step 302). Then,
25 the focusing estimated value creating device 23 creates the focusing estimated value by monitoring a level of this frequency component (step 303). For example, when

the level of the selected frequency component rises, it is estimated that the focus adjusting lens 11 is moving in such a direction as to approach a focusing point. Further, when the level of the selected frequency component lowers, it is estimated that the focus adjusting lens 11 is moving in such a direction as to get away from the focusing point. Then, when the level of the selected frequency component exists within a predetermined range (shown by, e.g., ΔV in Fig. 51) from the peak value, it is estimated that the image on the imaging element 21 is focused on.

Note that the processing flow shown in Fig. 43 is repeatedly executed at a predetermined time interval taking a processing speed, etc. in the picture signal creating device 22 into consideration.

Next, an operation of the second focusing estimating part 3 in the eleventh embodiment will be explained with reference to Fig. 44.

To start with, the positional deviation detecting portion 36a detects a deviating direction and a deviation quantity between the images picked up by the line sensors 34a, 34b on the basis of the signals transmitted from the image processing device 35 (step 401). As stated in the prior art, when the light beams traveling through the image forming lens 32 are focused on the predetermined focal surface 37, some of the light beams are again formed on the line sensors 34a,

34b by the image re-forming lenses 33a, 33b. Hence, if
focused on the predetermined focal surface 37, the
images picked up by the two line sensors 33a, 33b are
formed in substantially coincident positions on the
5 line sensors. On the other hand, when the light beams
passing through the image forming lens 32 are focused
on anterior to the predetermined focal surface 37
(which is the so-called rear focus state), there must
be a deviation between the images picked up by the two
10 line sensors 34a, 34b. Also, when the light beams
passing through the image forming lens 32 are focused
on posterior to the predetermined focal surface 37
(which is the so-called front focus state), there must
be a deviation in a direction opposite to the one in
15 the rear focus state between the images picked up by
the two line sensors 34a, 34b. Based on the deviating
direction and deviation quantity between the images
picked up by the line sensors 34a, 34b, it can be
therefore estimated how far the image on the
20 predetermined focal surface 37 exists away from the
focusing point.

Next, the correcting portion 36b corrects the
image positional deviation detected by the positional
deviation detecting portion 36a, with the correction
25 value stored in the defocus storage device 7 (step
402). Incidentally, the following is an elucidation of
the reason why the image positional deviation detected

by the positional deviation detecting portion 36a is corrected with the correction value stored in the defocus storage device 7.

5 If the predetermined focal surface 37 and the imaging element 21 of the first focusing estimating part 2 are coincident with each other in terms of their optical positions, viz., if the image on the imaging element 21 is focused on when the image on the predetermined focal surface 37 is focused on, there can
10 be directly made an estimation as to whether or not the image on the imaging element 21 is focused on in accordance with the image deviating direction and quantity that are detected by the positional deviation detecting portion 36a. However, if the optical
15 positions of the predetermined focal surface 37 and of the imaging element 21 deviate from each other, and if the predetermined focal surface 37 and the imaging element 21 deviate in terms of their optical positions due to, e.g., a tracking adjustment, the image on the
20 imaging element 21 is not focused on when the image on the predetermined focal surface 37 is focused on. Therefore, the estimation as to whether or not the image on the imaging element 21 is focused on is made based on the image deviating direction and quantity
25 that are detected by the positional deviation detecting portion 36a, the focusing accuracy declines. This being the case, the correcting portion 36b corrects the

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quantity between the images picked up by the line
sensors 34a, 34b that are detected by the positional
deviation detecting portion 36a, i.e., a defocus
quantity between the image on the predetermined focal
5 surface 37 and the image on the imaging element 21 of
the focusing estimating part 2.

Note that the processing flow shown in Fig. 45 may
be executed according to a command from the user or the
like. For example, when the command of the user is
10 inputted to a predetermined button, a slide switch and
so on, the processing flow shown in Fig. 45 may be
executed. With this operation, when under a
photographic condition enough to ensure a detection
accuracy of the level detecting portion 23a and of the
15 positional deviation detecting portion 36a, the user
switches ON the predetermined button or slide switch,
thereby making it possible to detect the defocus
quantity with a high precision between the image on the
predetermined focal surface 37 and the image on the
20 imaging element 21. The processing flow shown in Fig.
45 may also be repeatedly executed during the operation
of the apparatus in the eleventh embodiment. A
plurality of correction values may be thereby obtained,
and, from these plurality of correction values, the
25 defocus quantity between the image on the predetermined
focal surface 37 and the image on the imaging element
21 is estimated, whereby the accuracy of the correction

value can be enhanced. Moreover, the user performs the tracking adjustment or the like, and, even if the defocus quantity between the image on the predetermined focal surface 37 and the image on the imaging element 21 changes, a new defocus quantity can be automatically stored.

In accordance with the eleventh embodiment, the first focusing estimating part 2 creates the first focusing estimated value by use of the so-called crest climbing method, while the second focusing estimating part 3 creates the second focusing estimated value by employing the so-called image deviation method. Further, the focusing method selecting device 4 selects the second focusing estimated value when the second focusing estimated value created by the second focusing estimating part 3 is above the threshold value, and selects the first focusing estimated value when under the threshold value. Then, the motor driving device 6, based on the focusing estimated value selected by the focusing method selecting device 4, drives the motor 5 to move the focus adjusting lens 11. With this operation, to begin with, the image on the imaging element 21 is roughly focused on by use of the second focusing estimated value, and thereafter the image on the imaging element 21 is finely focused on by use of the first focusing estimated value. Accordingly, in accordance with the eleventh embodiment, the image on



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second focusing estimated value declines, the final focusing accuracy of the image on the imaging element 21 does not change. If the focusing accuracy of the second focusing estimated value declines, however, a
5 time of focusing operation involving the use of the first focusing estimated value created by the first focusing estimating part 2 elongates correspondingly. As a result, a time needed for focusing the image on the imaging element 21 elongates. In this respect,
10 according to the eleventh embodiment, as discussed above, the focusing accuracy of the second focusing estimated value can be prevented from declining, and therefore, even if there might be caused the deviation between the optical positions of the predetermined
15 focal surface 37 and the imaging element 21 due to the tracking adjustment, etc., the image on the imaging element 21 can be focused on quickly with the high precision.

Furthermore, in the eleventh embodiment, a focal
20 length of the optical system for forming the images for detecting the image deviation on the line sensors 34a, 34b, is a synthetic focal length of the focus adjusting lens 11, the variable magnification lens 12, the correcting lens 13 and the image forming lens 32. On
25 the other hand, a focal length of the optical system for forming the image for the picture signal on the imaging element 21, is a synthetic focal length of the

focus adjusting lens 11, the variable magnification lens 12, the correcting lens 13 and the image forming lens 14. Therefore, the focal lengths of the optical system for forming the images for detecting the image deviation and of the optical system for forming the image for the picture signal, are varied by changing the configurations of the image forming lenses 14, 32, videlicet, the sizes of the images formed by the respective optical systems can be varied. For instance, the image forming lens 32 is constructed to enlarge the images for detecting the image deviation by increasing the focal length of the optical system for forming the images for detecting the image deviation, whereby the pixel pitches of the line sensors 34a, 34b become finer relatively to the above images. Hence, it is feasible to focus even a minute object. Further, for example, the image forming lens 32 is constructed to diminish the images for detecting the image deviation by shortening the focal length of the optical system for forming the images for detecting the image deviation, whereby the sizes of these images become smaller relatively to the line sensors 34a, 34b. Therefore, it is possible to detect a larger quantity of image deviation. Even if the focus adjusting lens is positioned far from the focusing point (which is the so-called largely defocused state), the focusing point can be thereby quickly detected. Also, the apparatus

can be downsized.

The present invention is not confined to the embodiment discussed above but may be modified in a variety of forms within the scope of the gist thereof.

5 For example, in the eleventh embodiment, the defocus storage device 7 has been thus far explained as the one for storing the positional deviation between the images on the line sensors 34a, 34b that is detected by the positional deviation detecting portion 36a as the
10 defocus quantity between the image on the predetermined focal surface 37 and the image on the imaging element 21 of the focusing estimating part 2 when the first focusing estimating part 2 creates the first focusing estimated value indicating that the image on the
15 imaging element 21 is focused on. The present invention is not, however, limited to this. For instance, a defocus quantity detected when manufacturing the camera to which the eleventh embodiment is applied and a defocus quantity predicted
20 when designed, may be previously written to a ROM, etc..

Further, the eleventh embodiment has been described so far, wherein there are provided the first focusing estimating part of the crest climbing type and
25 the second focusing estimating part of the image deviation type, the correction value is used for the second focusing estimated value created by the second

5 for creating the focusing estimated values for focusing
the image upon the object, which image is formed on the
predetermined plane by the photographing optical
system, the storage device stored with the correction
value for the focusing estimated value created at least
10 one of these focusing estimating parts, and the
correcting portion for correcting the focusing
estimated value with the correction value, which
estimated value corresponds to the correction value
stored in the storage device.

A twelfth embodiment of the present invention will
20 be hereinafter discussed with reference to the
drawings.

Fig. 46 is a schematic block diagram illustrating an autofocus apparatus in the twelfth embodiment of the present invention. Fig. 47 is an explanatory flowchart showing an operation of the autofocus apparatus
25 illustrated in Fig. 46. Fig. 48 is an explanatory flowchart showing an operation of the first focusing

estimating part illustrated in Fig. 46. Fig. 49 is an explanatory flowchart showing an operation of the second focusing estimating part shown in Fig. 46.

5 The autofocus apparatus in the twelfth embodiment includes, as illustrated in Fig. 46, the photographing optical system 1, the first focus estimating part 2, the second focusing estimating part 3, the focusing method selecting device 4, the motor 5, the motor driving device 6, and a position detecting device 17.

10 Incidentally, if the autofocus apparatus in the twelfth embodiment is applied to the video camera, etc., it is a general construction that the lens barrel incorporates the photographing optical system 1 and the motor 5, while the camera body incorporates other

15 constructive elements. The present invention is not, however, limited to this construction.

The photographing optical system 1 is constructed of four lens units such as the focus adjusting lens 11, the variable magnification lens 12, the correcting lens 13, and the image forming lens 14. This construction

20 is typical of the lens barrel for a TV camera. In the photographing optical system 1 used in the twelfth embodiment, the optical element (e.g., the beam splitter) 45 for splitting light beams and the stop 16

25 are interposed in between the correcting lens 13 and the image forming lens 14. Note that the optical element 45 is disposed anterior to the stop 16 so that

the light beams can be transmitted to the second focusing estimating part 3 irrespective of an aperture quantity of an aperture stop of the photographing optical system 1 in the twelfth embodiment.

5 The position detecting device 17 detects an item of data for specifying a position of the image forming lens 14.

10 The first focusing estimating part 2 estimates focusing by the so-called crest climbing method. The first focusing estimating part 2 includes the imaging element 21 for picking up an image formed by the image forming lens 14 of the photographing optical system 1 and converting it into an electric signal, and the picture signal making device 22 for generating a
15 picture signal corresponding to the electric signal transmitted from the imaging element 21. The first focusing estimating part 2 also includes the focusing estimated value creating device 23 for creating the data (the first focusing estimated value) for focusing
20 the image formed on the imaging element 21 on the basis of the picture signal given from the picture signal making device 22. The focusing estimated value creating device 23 has the level detecting portion 23a for detecting a level of a proper frequency component
25 from the picture signal generated by the picture signal making device 22, and the estimated value creating portion 23b for creating the first focusing estimated

value by examining the level detected by the level
detecting portion 23a. Note that the electric signal
outputted from the imaging element 21 is used also for
generating the picture signal of the video camera as
5 illustrated in Fig. 46.

The second focusing estimating part 3 estimates
focusing by the so-called image deviation method. The
second focusing estimating part 3 comprises the mirror
31 for reflecting the light beam split by the optical
10 element 45, toward a predetermined direction, and the
image forming lens 32 for forming light beams incident
via the mirror 31 into a conjugate image. The second
focusing estimating part 3 further comprises the image
re-forming lenses 33a, 33b for forming some of the
15 light beams image formed by the image forming lens 32,
again into images, the line sensors 34a, 34b for
respectively picking up the images formed by the image
re-forming lenses 33a, 33b and converting them into
electric signals, the image processing device 35, and
20 the focusing estimates value creating device 36.

The image re-forming lenses 33a, 33b are disposed
in positions substantially symmetric with respect to
the optical axis of the image forming lens 32. More
specifically, the image reforming lenses 33a, 33b are
25 so disposed as to individually re-form the images of
the light beams passing through portions having
different pupils in the optical system consisting of

the focus adjusting lens 11, the variable magnification lens 12, the correcting lens 13 and the image forming lens 32, among the light beams for forming the image formed by the image forming lens 32. The line sensors 5 34a, 34b are disposed in the positions substantially symmetric with respect to the optical axis of the image forming lens 32 and on a predetermined focal surface of the image re-forming lenses 33a, 33b corresponding to each other. The image processing device 35 executes 10 the image processing based on the electric signals transmitted respectively from the line sensors 34a, 34b. The focusing estimated value creating device 36 creates the data (the second focusing estimated value) for focusing the image on the imaging element 21 on the 15 basis of the signal transmitted from the image processing device 35. The focusing estimated value creating device 36 includes the positional deviation detecting portion 36a for detecting an imaging positional deviation (a deviating direction and a 20 deviation quantity) between the image on the imaging element 34a and the image on the imaging element 34b on the basis of the signal transmitted from the image processing device 35, the correcting portion 36b for correcting the imaging positional deviation detected by 25 the positional deviation detecting portion 36a, and the estimated value creating portion 36b for creating the second focusing estimated value based on the imaging

positional deviation corrected by the correcting portion 36b.

5 The correcting portion 36b is stored with a table showing a relationship between the position of the image forming lens 14 and the imaging positional deviation detected by the positional deviation detecting portion 36a when focusing the image on the imaging element 21 upon the object. The correcting portion 36b obtains an imaging positional deviation
10 corresponding to the position data of the image forming lens 14, which is detected by the position detecting device 7 from that table, and corrects the imaging positional deviation detected by the positional deviation detecting portion 36a, with the thus obtained
15 imaging position deviation serving as a correction value.

20 The focusing method selecting device 4 selects at least one of the first focusing estimated value created by the first focusing estimating part 2 and the second focusing estimated value created by the second focusing estimating part 3. In accordance with the twelfth embodiment, referring first to the second focusing estimated value, if the defocus quantity or the required-for-focusing moving quantity of the focus
25 adjusting lens 11 is larger than a threshold value, the second focusing estimated value is set to be selected, and, if smaller than the threshold value, the first

focusing estimated value is set to be selected. Note that this threshold value may also be set arbitrarily by the photographer and so forth through inputting from outside.

5 The motor driving device 6 drives the motor 5 on the basis of the focusing estimated value selected by the focusing method selecting device 4. Based on a command given from the motor driving device 6, the motor 5 moves the focus adjusting lens 11 forward and
10 backward in the optical-axis direction of the photographing optical system 1.

 Incidentally, the focusing estimated value creating devices 23, 36, and the focusing method selecting device 4 are integrally constructed of, e.g.,
15 the CPU (Central Processing Unit), etc..

 Next, an operation of the autofocus apparatus in the twelfth embodiment will be described.

 To start with, the operation of the autofocus apparatus as a whole in the twelfth embodiment will be
20 explained with reference to Fig. 47.

 At first, upon an incidence of the light beams upon the photographing optical system 1 from the object, the first focusing estimating part 2 creates the first focusing estimated value on the basis of the
25 light beams obtained via the image forming lens 14 in the photographing optical system 1. Further, the second focusing estimating part 3 creates the second

focusing estimated value based on the light beams split by the optical element 45 in the photographing optical system 1 (step 271).

Next, the focusing method selecting device 4
5 judges whether or not the first focusing estimated value gives an indication of being focused (step 272). If the first focusing estimated value indicates a purport of being focused, a flow of processing shown in Fig. 47 comes to an end. Whereas if not, the
10 processing proceeds to step 273.

In step 273, the focusing method selecting device 4 refers to the second focusing estimated value, and judges whether or not the defocus quantity or the required-for-focusing moving quantity of the focus
15 adjusting lens 11 is under the threshold value. If the required-for-focusing moving quantity of the focus adjusting lens 11 is under the threshold value, the first focusing estimated value created by the first focusing estimating part 2 is selected (step 274).
20 Whereas if above the threshold value, the second focusing estimated value selected by the second focusing estimating part 3 is selected (step 275).

Next, the motor driving device 6 drives the motor on the basis of the focusing estimated value selected
25 by the focusing method selecting device 4 (step 276). When the second focusing estimated value is selected by the focusing method selecting device 4, the motor

driving device 6 drives the motor 5 so that the focus
adjusting lens 11 is moved in the moving direction by
the moving quantity, which are indicated by the
selected second focusing estimated value. Further,
5 when the first focusing estimated value is selected by
the focusing method selecting device 4, it is estimated
that the focus adjusting lens 11 is moving in such a
direction as to approach a focusing point. At this
time, the motor 5 is driven to make the rotating
10 direction thereof remain unchanged. Moreover, when it
is estimated that the focus adjusting lens 11 is moving
in such a direction as to get away from the focusing
point, the motor 5 is driven to reverse the rotating
direction thereof.

15 The processing flow shown in Fig. 47 is repeatedly
executed till the first focusing estimated value comes
to have a content of being focused. The image on the
imaging element 21 is thereby focused on.

Subsequently, an operation of the first focusing
20 estimating part 2 in the twelfth embodiment will be
explained with reference to Fig. 48.

At first, the picture signal making device 22
converts the image formed on the imaging element 21
through the photographing optical system 1 into a
25 picture signal (step 351). As described in the prior
art, the picture signal is, it can be assumed, formed
by synthesizing sine waves of a plurality of

frequencies. Then, it is well known that a level of high frequency component of the picture signal, as illustrated in Fig. 51, rises more sharply according as a degree of sharpness of the image formed on the

5 imaging element 21 increases, i.e., the focus adjusting lens 11 moves closer to a focusing point A, and this level reaches a peak when the image on the imaging element 21 is focused on. Subsequently, the focusing estimated value creating device 23 causes a level

10 detecting portion 23a to detect a proper high frequency component level at a predetermined sampling interval in consideration of an S/N ratio of the picture signal as well as of an imaging performance of the photographing optical system 1, out of the picture signal of the

15 picture signal making device 22 (step 352). Then, an estimated value creating portion 23b creates the first focusing estimated value by monitoring a change in the detected level (step 353). For example, when the level of the selected frequency component rises, it is

20 estimated that the focus adjusting lens 11 is moving in such a direction as to approach a focusing point. Further, when the level of the selected frequency component lowers, it is estimated that the focus adjusting lens 11 is moving in such a direction as to

25 get away from the focusing point. Then, when the level of the selected frequency component exists within a predetermined range (shown by, e.g., ΔV in Fig. 51)

from the peak value, it is estimated that the image on the imaging element 21 is focused on.

Note that the processing flow shown in Fig. 48 is repeatedly executed at a predetermined time interval
5 taking a processing speed, etc. in the picture signal creating device 22 into consideration.

Next, an operation of the second focusing estimating part 3 in the twelfth embodiment will be explained with reference to Fig. 49.

10 To start with, the positional deviation detecting portion 36a detects a deviating direction and a deviation quantity between the images picked up by the line sensors 34a, 34b on the basis of the signals transmitted from the image processing device 35 (step
15 451). As stated in the prior art, when the light beams traveling through the image forming lens 32 are focused on the predetermined focal surface 37, some of the light beams are again formed on the line sensors 34a, 34b by the image re-forming lenses 33a, 33b. Hence, if
20 focused on the predetermined focal surface 37, the images picked up by the two line sensors 33a, 33b are formed in substantially coincident positions on the line sensors. On the other hand, when the light beams passing through the image forming lens 32 are focused
25 on anterior to the predetermined focal surface 37 (which is the so-called rear focus state), there must be a deviation between the images picked up by the two

line sensors 34a, 34b. Also, when the light beams passing through the image forming lens 32 are focused on posterior to the predetermined focal surface 37 (which is the so-called front focus state), there must
5 be a deviation in a direction opposite to the one in the rear focus state between the images picked up by the two line sensors 34a, 34b. Based on the deviating direction and deviation quantity between the images picked by the line sensors 34a, 34b, it can be
10 therefore estimated how far the image on the predetermined focal surface 37 exists away from the focusing point.

Next, the correcting portion 36b obtains the imaging positional deviation corresponding to the data
15 about the position of the image forming lens 14 which position is detected by the position detecting device from the stored table (step 452), and corrects the imaging positional deviation detected by the positional deviation detecting portion 36a, with the thus obtained
20 imaging positional deviation serving as a correction value (step 453). Incidentally, the following is an elucidation of the reason why the imaging positional deviation detected by the positional deviation detecting portion 36a is corrected based on the
25 position data of the image forming lens 14.

If the predetermined focal surface 37 and the imaging element 21 of the first focusing estimating

part 2 are coincident with each other in terms of their optical positions, viz., if the image on the imaging element 21 is focused on when the image on the predetermined focal surface 37 is focused on, there can
5 be directly made an estimation as to whether or not the image on the imaging element 21 is focused on in accordance with the image deviating direction and quantity that are detected by the positional deviation detecting portion 36a. However, if the optical
10 positions of the predetermined focal surface 37 and of the imaging element 21 deviate from each other, and if the predetermined focal surface 37 and the imaging element 21 deviate in terms of their optical positions due to, e.g., the tracking adjustment, the image on the
15 imaging element 21 is not focused on when the image on the predetermined focal surface 37 is focused on. Therefore, the estimation as to whether or not the image on the imaging element 21 is focused on is made based on the image deviating direction and quantity
20 that are detected by the positional deviation detecting portion 36a, the focusing accuracy declines. Such being the case, in the twelfth embodiment, the correcting portion 36b is stored with the table indicating the relationship between the position of the
25 image forming lens and the imaging positional deviation detected by the positional deviation detecting portion 36a when the image on the imaging element 21 is focused

on the object. Detected from this table is the imaging positional deviation corresponding to the data about the position of the image forming lens 14, which position is detected by the position detecting device 5 17. Then, the imaging positional deviation detected by the positional deviation detecting portion 36a is corrected, with the thus detected imaging positional deviation serving as a correction value.

Next, the estimated value creating portion 36c 10 creates the second focusing estimated value indicating a moving direction and a moving quantity of the focus adjusting lens 11, which are needed for focusing the image on the imaging element 21, on the basis of the positional deviating direction and quantity of the 15 imaging positional deviation corrected by the correcting portion 36b (step 454).

Note that the processing flow shown in Fig. 49 is repeatedly executed at a predetermined time interval in consideration of the processing speed, etc. in the 20 image processing device 35.

In the twelfth embodiment, the first focusing estimating part 2 creates the first focusing estimated value by use of the so-called crest climbing method, while the second focusing estimating part 3 creates the 25 second focusing estimated value by employing the so-called image deviation method. Further, the focusing method selecting device 4 selects the second focusing

estimated value when the second focusing estimated value created by the second focusing estimating part 3 is above the threshold value, and selects the first focusing estimated value when under the threshold value. Then, the motor driving device 6, based on the focusing estimated value selected by the focusing method selecting device 4, drives the motor 5 to move the focus adjusting lens 11. With this operation, to begin with, the image on the imaging element 21 is roughly focused on by use of the second focusing estimated value, and thereafter the image on the imaging element 21 is finely focused on by use of the first focusing estimated value. Accordingly, in accordance with the twelfth embodiment, the image on the imaging element 21 can be focused on quickly with a high accuracy. Further, the high accuracy is not required of the second focusing estimating part 3 using the image deviation method, and hence the costs can be restrained from rising.

Moreover, in the twelfth embodiment, the imaging positional deviation corresponding to the data of the position of the image forming lens 14 that is detected by the position detecting device 7, is detected from the table, with which the correcting portion 36b is stored, showing the relationship between the position of the image forming lens 14 and the imaging positional deviation detected by the positional deviation

detecting portion 36a when the image on the imaging
element 21 is focused on the object. Then, with the
detected imaging positional deviation serving as the
correction value, the imaging positional deviation
5 detected by the positional deviation detecting portion
36a is corrected. Therefore, even if there might be
caused the deviation between the optical positions of
the predetermined focal surface 37 and of the imaging
element 21 because of the image forming lens 14 being
10 moved due to, e.g., the tracking adjustment with the
result that the image on the imaging element 21 is not
focused on when the image on the predetermined focal
surface 37 is focused on, the focusing accuracy of the
second focusing estimated value can be prevented from
15 declining.

Note that the image on the imaging element 21 is
focused on by use of the first focusing estimated value
in the end in accordance with the twelfth embodiment,
and hence, even when the focusing accuracy of the
20 second focusing estimated value declines, the final
focusing accuracy of the image on the imaging element
21 does not change. If the focusing accuracy of the
second focusing estimated value declines, however, a
time of focusing operation involving the use of the
25 first focusing estimated value created by the first
focusing estimating part 2 elongates correspondingly.
As a result, a time needed for focusing the image on

the imaging element 21 elongates. In this respect, according to the twelfth embodiment, as discussed above, the focusing accuracy of the second focusing estimated value can be prevented from declining, and
5 therefore, even if there might be caused the deviation between the optical positions of the predetermined focal surface 37 and the imaging element 21 due to the tracking adjustment, etc., the image on the imaging element 21 can be focused on quickly with the high
10 precision.

Furthermore, in the twelfth embodiment, a focal length of the optical system for forming the images for detecting the image deviation on the line sensors 34a, 34b, is a synthetic focal length of the focus adjusting
15 lens 11, the variable magnification lens 12, the correcting lens 13 and the image forming lens 32. On the other hand, a focal length of the optical system for forming the image for the picture signal on the imaging element 21, is a synthetic focal length of the
20 focus adjusting lens 11, the variable magnification lens 12, the correcting lens 13 and the image forming lens 14. Therefore, the focal lengths of the optical system for forming the images for detecting the image deviation and of the optical system for forming the
25 image for the picture signal, are varied by changing the configurations of the image forming lenses 14, 32, videlicet, the sizes of the images formed by the

respective optical systems can be varied. For instance, the image forming lens 32 is constructed to enlarge the images for detecting the image deviation by increasing the focal length of the optical system for forming the images for detecting the image deviation, whereby the pixel pitches of the lines sensors 34a, 34b become finer relatively to the above images. Hence, it is feasible to focus even a minute object. Further, for example, the image forming lens 32 is constructed to diminish the images for detecting the image deviation by shortening the focal length of the optical system for forming the images for detecting the image deviation, whereby the sizes of these images become smaller relatively to the line sensors 34a, 34b. Therefore, it is possible to detect a larger quantity of image deviation. Even if the focus adjusting lens is positioned far from the focusing point (which is the so-called largely defocused state), the focusing point can be thereby quickly detected. Also, the apparatus can be downsized.

Next, a thirteenth embodiment of the present invention will be hereinafter discussed with reference to the drawings.

Fig. 50 is a schematic block diagram illustrating the autofocus apparatus in the thirteenth embodiment of the present invention. Note that the elements having the same functions as those in the twelfth embodiment

shown in Fig. 46 are marked with the like or corresponding numerals in the thirteenth embodiment of the present invention, and the detailed explanations thereof are omitted.

5 A different point of the autofocus apparatus in the thirteenth embodiment from the twelfth embodiment shown in Fig. 46, is that a second focusing estimating part 3a substitutes for the second focusing estimating part 3, and there are provided a motor 18 and a motor
10 driving device 19.

 The second focusing estimating part 3a is different from the second focusing estimating part 3 shown in Fig. 46 in terms of such a point that an image forming lens 32a for forming the light beams incident
15 via the mirror 31 and emerging from the object into a conjugate image, is so disposed as to be movable in the optical-axis direction and that the focusing estimated value creating device 38 does not include the
20 correcting portion 36b. The focusing estimated value creating device 38 makes the estimated value creating portion 36c create the second focusing estimated value based on the deviating direction and the deviation quantity of the imaging positional deviation detected by the positional deviation detecting portion 36a.

25 The motor driving device 19 is stored with a table showing a relationship between the position of the image forming lens 14 and the position of the image

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forming lens 32a, from which the image on the imaging
element 21 and the image on the predetermined focal
surface 37 become conjugate to each other. The motor
driving device 19 obtains the position of the image
5 forming lens 32a which corresponds to data about the
position of the position of the image forming lens 14,
which position is detected by the position detecting
device 17 from that table, and drives the motor 18 so
that the image forming lens 32a comes to this obtained
10 position. Incidentally, if a formula well expresses
the relationship between the position of the image
forming lens 14 and the position of the image forming
lens 32a, from which the images on the imaging element
21 and the image on the predetermined focal surface 37
15 become conjugate to each other, the position of the
image forming lens 32a that corresponds to the data of
the position of the image forming lens 14 which
position is detected by the position detecting device
17, may be obtained by use of this formula instead of
20 using the above table.

Based on a command from the motor driving device
19, the motor 18 moves the image forming lens 32a in
the optical-axis direction thereof.

In the thirteenth embodiment, the position of the
25 image forming lens 32a that corresponds to the data of
the position of the image forming lens 14 which
position is detected by the position detecting device

17, is detected from the table stored in the motor driving device 19 and showing the relationship between the position of the image forming lens and the position of the image forming lens 32a, from which the image on the imaging element 21 and the image on the predetermined focal surface 37 become conjugated to each other. Then, the image forming lens 32a is moved so that the image forming lens 32a comes to the detected position concerned. Therefore, even when the image forming lens 14 moves due to, e.g., the tracking adjustment, it is possible to prevent the deviation in the optical positions between the predetermined focal surface 37 and the imaging element 21. This further makes it feasible to prevent the focusing accuracy of the second focusing estimated value from declining. Other effects are the same as those in the twelfth embodiment of the present invention.

The present invention is not confined to the respective embodiments discussed above by may be modified in a variety of forms within the scope of the gist thereof. For example, in each of the embodiments given above, the apparatus has been described so far, wherein the crest climbing type first focusing estimating part and the image deviation type second focusing estimating part, are provided, and the focusing estimated value created by the second focusing estimating part is corrected. The present invention is

not, however, limited to this. The apparatus according to the present invention may comprise the plurality of focusing estimating parts for creating the focusing estimated values for focusing, on the object, the image
5 formed on the predetermined plane through the photographing optical system. The apparatus may also comprise the position detecting portion for detecting the position data of the image forming lens in the photographing optical system, and the position
10 detecting portion for detecting the position data of the image forming lens in the photographing optical system. The apparatus may further comprise the correcting portion for correcting the focusing data created by at least one of the focusing estimating
15 parts on the basis of the data about the position of the image forming lens, which position is detected by the position detecting portion.

Moreover, the autofocus apparatus in the embodiments discussed above is applicable to not only
20 the video camera but also other cameras such as an electronic still camera and so on.

As discussed above, in the autofocus apparatus according to the present invention, the first focusing estimating device creates the focusing estimated value,
25 involving the use of the so-called crest climbing method. The second focusing estimating device creates the focusing estimated value, involving the use of the

so-called image deviation method. Then, the focusing estimation selecting device selects at least one of the focusing estimated values created by the first and second focusing estimating devices, and the focus
5 adjusting lens is moved based on the thus selected focusing estimated value.

Hence, according to the autofocus apparatus of the present invention, to begin with, the image on the first imaging element is roughly focused on by use of
10 the focusing estimated value of the second focusing estimating device, and thereafter the image on the first imaging element is finely focused on by use of the focusing estimated value of the first focusing estimating device. It is therefore feasible to perform
15 the focusing quickly with the high accuracy.

Further, according to the autofocus apparatus of the present invention, if one of the first and second focusing estimated values is useless, the focusing on the object can be surely performed by selecting the
20 other estimated value.

Moreover, according to the autofocus apparatus of the present invention, at least one of the first and second focusing estimated values is selected referring to the depth of field. With this operation, if the
25 focusing accuracy in the first focusing estimating device is inferior to the focusing accuracy in the second focusing estimating device, the focusing

estimation selecting device can be set to select the data from the second focusing estimating device. The focusing can be thereby effected quickly with the high precision.

5 Also, when the autofocus apparatus of the present invention is provided with the above-constructed object dimension calculating device, the object dimension setting device and the focusing object controlling device, it is possible to focus on only a specified
10 object (e.g., human being) from within the photographic area by focusing on the relevant object only when, for instance, the object real dimension calculated by the object dimension calculating device is coincident with
15 the dimension of the photographing target, which dimension is set by the object dimension setting device.

 Additionally, when the autofocus apparatus of the present invention is provided with the above-constructed focus area setting device, for example, the
20 focus area of the first focusing estimating device is set smaller than the focus area of the second focusing estimating device. A detection sensitivity of the imaging positional deviation in the second focusing estimating device can be thereby decreased. This
25 enables a resolution of the second imaging element to increase, and therefore the cost for the second focusing estimating device can be restrained.

Further, in other autofocus apparatuses of the present invention, with the constructions given above, for instance, only when the object real dimension calculated by the object dimension calculating device is coincident with the photographing target dimension set by the object dimension setting device, the focusing on the object concerned is carried out. Thus, it is feasible to focus on only the specified object (e.g., human being) from within the photographic area.

Furthermore, the camera according to the present invention has the above construction and therefore exhibits the same effects as those in the autofocus apparatus of the present invention.

According to the lens barrel of the present invention, with the construction described above, the image on the imaging element can be focused on by employing the two types, i.e., the crest climbing type and the image deviation type of the autofocus systems. Owing to this construction, at first, the image on the imaging element is roughly focused on by using the image deviation method, and, thereafter, the image on the imaging element is finely focused on by using the crest climbing method. The image on the imaging element can be thereby focused on quickly with the high accuracy. Further, since the camera body incorporates the first focusing estimating part usable in common irrespective of the structure of the photographing

optical system, the lens barrel can be prevented from rising in costs and can be downsized.

Moreover, according to the lens barrel of the present invention, the lens barrel incorporates the two
5 types, viz., the crest climbing type and the image deviation type of the autofocus mechanisms, whereby the image on the imaging element can be focused on quickly with the high precision even if the camera body is constructed not corresponding to the autofocusing.

10 According to the camera of the present invention, owing to the construction given above, if the camera body does not include the first focusing estimating device, the autofocus function can be actualized by employing the second focusing estimating device of the
15 lens barrel. Further, if the camera body has the first focusing estimating device, the autofocus function can be actualized by using the second focusing estimating device of the lens barrel as well as using the first focusing estimating device of the camera body.

20 According to the lens barrel of the present invention, the lens barrel incorporates the crest climbing type autofocus mechanism, thereby enabling the image on the imaging element to be focused on highly accurately even though the camera body is constructed
25 not corresponding to the autofocus.

According to the lens barrel of the present invention, the lens barrel is provided with the image

5 Moreover, according to the present invention, for
example, there are provided the crest climbing type and
image-deviation type focusing estimating devices. To
start with, the image on the predetermined plane is
roughly focused on by use of the focusing data of the
10 image deviation type focusing estimating device.
Thereafter, the selecting device is set so that the
image on the predetermined plane is finely focused on
by making use of the focusing data of the crest
climbing type focusing estimating device. Thus the
15 focusing can be done quickly with the high accuracy.

Moreover, as one of the plurality of focusing
estimating devices, the light beams diverge from the
photographing optical system for forming the image on
the imaging surface of the camera body as in the image
deviation type focusing estimating device, and the
image is formed in a different position from the above
imaging surface, thus estimating whether or not the
image on the imaging surface is focused on by use of
the relevant image. Even when using this estimating
system, the storage device stores, as the correction
value, the deviation in the optical positional
relationship between the imaging surface of the camera

body and the surface formed with the image for focusing estimation, and the focusing data of the corresponding focusing estimating device is corrected by using the thus stored correction value, thereby making it
5 feasible to prevent the decline in the focusing accuracy when employing the relevant focusing estimating device.

Further, as one of the plurality of focusing estimating devices, the light beams diverge from the
10 photographing optical system for forming the image on the imaging surface of the camera body as in the image deviation type focusing estimating device, and the image is formed in a different position from the above imaging surface, thus estimating whether or not the
15 image on the imaging surface is focused on by use of the relevant image. Even when using this estimating system, the position data of the image forming lens is detected, and there is obtained the deviation in the optical positional relationship between the imaging
20 surface of the camera body and the surface formed with the image for focusing estimation. Then, the focusing data of the corresponding focusing estimating device is corrected with the thus obtained deviation serving as the correction value, thereby making it possible to
25 prevent the decline in the focusing accuracy when using the relevant focusing estimating device.

It is apparent that, in this invention, a wide

5